28

SPACE SYSTEMS

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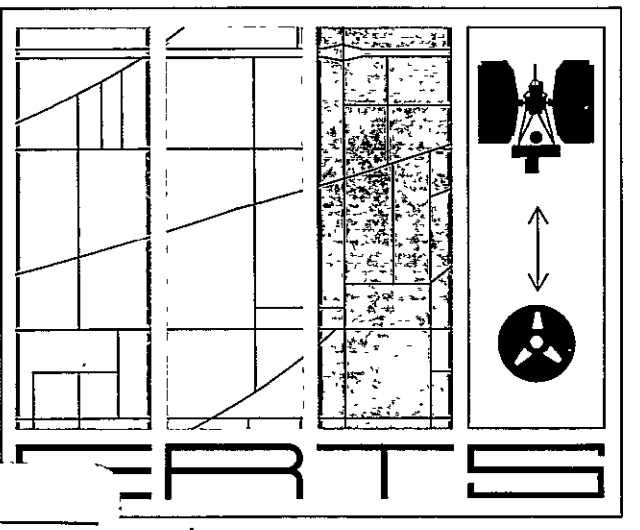
EARTH RESOURCES TECHNOLOGY SATELLITE SPACECRAFT SYSTEM DESIGN STUDIES FINAL REPORT

VOLUME III

PERFORMANCE ASSURANCE



Prepared For

GODDARD SPACE FLIGHT CENTER

GREENBELT, MARYLAND 20771

GENERAL ELECTRIC

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VOLUME III

PERFORMANCE ASSURANCE

PREPARED FOR:

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND 20771

UNDER

CONTRACT NO. NAS 5–11529

GENERAL ELECTRIC

SPACE SYSTEMS ORGANIZATION
Valley Forge Space Center
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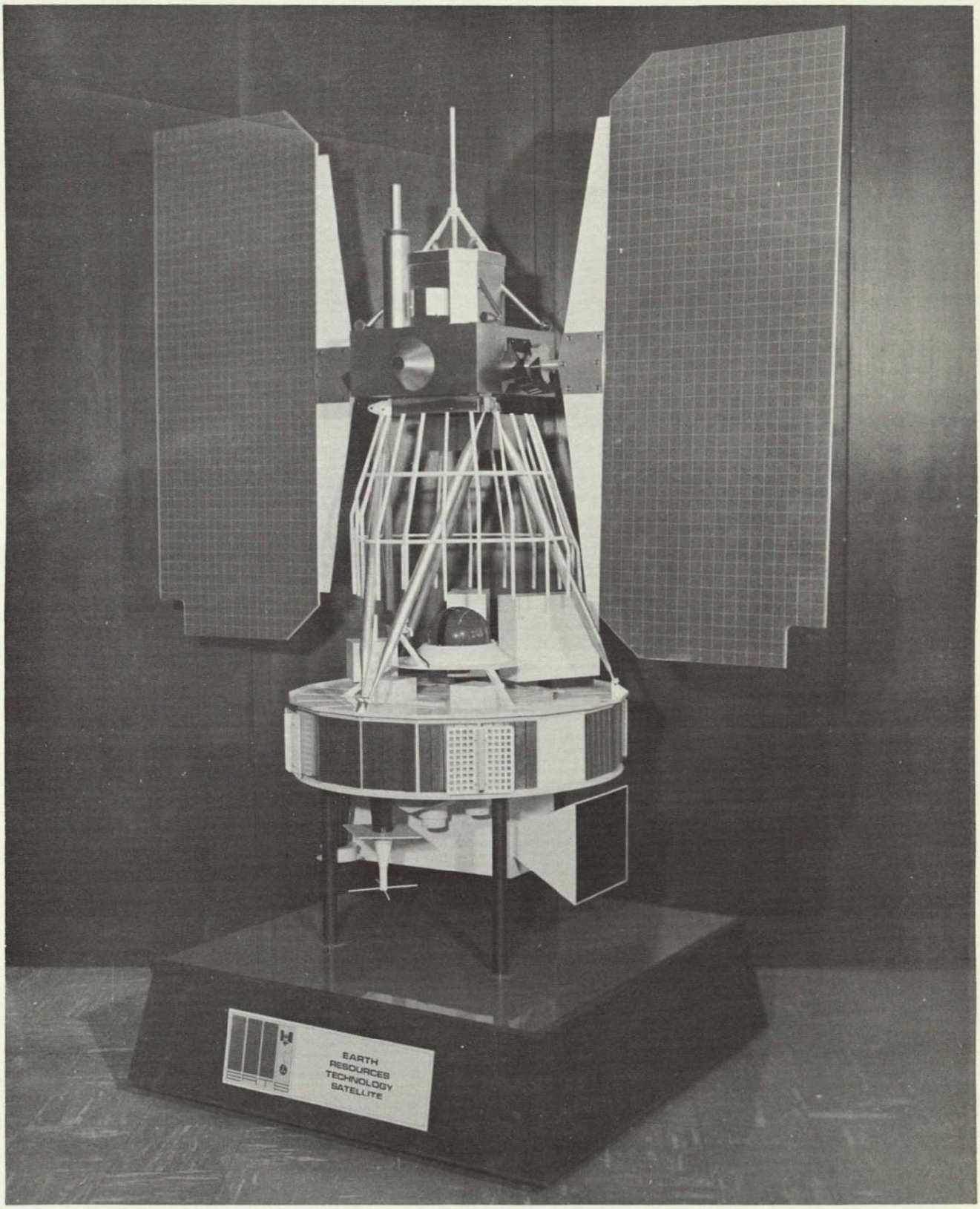
EARTH
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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF ACRONYMS

NDPF	NASA Data Processing Facility
NTTF	NASA Tracking and Training Facility
WBVTR	Wide Band Video Tape Recorder
MSS	Multi-Spectral Scanner
RBV	Return Beam Vidicon
WB	Wide Band
RBVC	Return Beam Vidicon Camera
DCS	Data Collection System
OCC	Operations Control Center
TLM	Telemetry
NB	Narrow Band
MSFN	Manned Space Flight Network
nm	Nautical Mile
M	Meters
PCM	Pulse Code Modulated
I/O	Input/Output
STADAN	Satellite Tracking and Data Acquisition Network
AGE	Aerospace Ground Equipment (also equivalent to GSE or STE)
PMP	Premodulation Processor
CIU	Command Integration Unit
COMDEC	Command Decoder
PCM/FSK	Pulse Code Modulated/Frequency Shift Keyed
Nort.	Nortronics
FHC	Fairchild-Hiller Corp.
Cal Comp	California Computer Co.
PCM/PSK	Pulse Code Modulated/Phase Shift Keyed
IRLS	Interrogation, Recording and Location Subsystem
ITP	Integrated Test Plan
BIT	Bench Integrated Test
T/V	Thermal Vacuum
WTR	Western Test Range
GFE	Government Furnished Equipment
C&DH	Command and Data Handling Subsystem
VIP	Versatile Information Processor
SASS	Solar Array Sun Sensor
RWS	Reaction Wheel Scanner
SAD	Solar Array Drive
ADP	Automatic Data Processing
SWR	Standing Wave Ratio
RDT	Raw Data Tape
RMP	Rate Measuring Package
YIRU	Yaw Inertial Reference Unit
LN	Lead Network
RSAD	Right Solar Array Drive
HAC	Horizon Attitude Computer
ACS	Attitude Control Subsystem
PSA	Pneumatic Subassembly

SECTION 1

INTRODUCTION

SECTION 1

INTRODUCTION

The Performance Assurance activities at General Electric Space Systems is a comprehensive approach toward obtaining high spacecraft performance, reliability and workmanship consistent with the one year in orbit ERTS mission. To accomplish this, a formal set of plans have been established for Quality Assurance, Reliability, Configuration Management, and Test Monitor and Control. Implementation of the plans have single-point visibility through a Manager of Performance Assurance for the ERTS program who will direct the related activities for the ERTS Program Manager through all phases of the program. A summary of these activities follows:

1.1 DESIGN/DEVELOPMENT PHASE

During this phase of the program the Performance Assurance tasks will involve the Reliability, Quality Assurance and Configuration Management elements. Activities during this period have the greatest impact on overall program reliability and must assure the systematic removal of design defects prior to incorporation into the hardware. Design specifications will be reviewed for their impact on reliability and quality, formal design reviews will be held, and potential problem areas will be identified. Reliability prediction and estimation will be accomplished. Critical potential failure areas will be evaluated using the Failure Mode Effect and Criticality Analysis (FMECA); Parts and Materials selection and application will be evaluated for derating factors and dominant failure stresses. Evaluation of potential process problems, ability to inspect and test will occur during the design development phase. A configured articles list (baseline) will be formulated and subsequent changes will be processed through the Configuration Control Board (CCB).

1.2 PROCUREMENT/FABRICATION PHASE

Many of the major subcontractors have been selected on the basis of utilizing existing designs from Nimbus. For new supplier selection, past performance will be evaluated and surveys conducted as required to assure their ability to meet the ERTS Performance Assurance requirements. Purchase Orders are reviewed prior to release to assure that the Performance Assurance requirements are effectively documented. The supplier compliance documents such as the Quality Plan, Reliability Plan, Process Controls, Parts Control, Flow Plans, Test Plans, Failure Reporting and Analysis Plans will be reviewed by the applicable Performance Assurance functions. Continued supplier control is implemented throughout the program in activities such as design review, change control, failure investigation, material review, monitoring of manufacturing, inspection, and test activities and adherence to procedures. Upon receipt of supplier items at GE, receiving inspection and testing is performed to detailed instructions as required to assure quality status.

Detailed inspection planning is utilized during the fabrication cycle for inspection and configuration verification. Control of processes such as soldering, welding, bonding, etc., will be monitored. Up-to-date configuration status is maintained in history files. Discrepancies are documented, problems investigated and corrective action implemented through a Material Review Board. Inspection is performed during vehicle assembly as defined in inspection planning.

1.3 TEST PHASE

Testing occurs at many levels of fabrication, starting with incoming materials and parts acceptance, which is done to detailed instructions by Performance Assurance personnel. Testing is performed on modules before and after potting. Testing at the black box or component level is conducted to detailed, controlled procedures which specify the equipment and environmental conditions for the tests. The procedures are written by the responsible quality engineer and approved by the design engineer. Test factor checkout, including fixtures, equipment and procedures, is accomplished with the quality engineer and test personnel. Tests are monitored by the quality engineers who approve the test data. Log books are maintained on all significant events and a final test report generated. The Integrated Test Program Board (ITPB) determines final acceptance of the component. Test failures that occur are formally documented as described in the ERTS Failure Reporting and Analysis Plan. Failures are investigated and isolated by the quality engineer and design engineer. Formal failure analyses are performed and documented as required including identification and implementation of corrective action to prevent failure recurrence.

Testing at the systems level is performed by ERTS test teams and monitored by inspection personnel to verify use of approved test procedures, verify configuration, test setup and to compare results with acceptance criteria. Inspection personnel maintain significant events logs, connector mate and demate history, operating time logs, and weight logs in addition to monitoring safety cleanliness and equipment calibration. Problem reports, nonconformance reports and Goddard Malfunction Reports are generated as described in the ERTS Failure Reporting and Analysis Plan. Appropriate configuration, inspection and test data is accumulated by the configuration management office and presented for final vehicle buy-off.

The system test teams travel with the vehicle to the launch site where testing and checkout is performed at the SAB and launch site to assure that the vehicle is ready for flight.

The following sections and Appendixes to Volume III discuss in detail the Performance Assurance activities that will be performed on the ERTS Program.

SECTION 2

QUALITY PROGRAM PLAN
ERTS A&B

SECTION 2

QUALITY PROGRAM PLAN
ERTS A&B

2.1 INTRODUCTION

2.1.1 GENERAL

This ERTS Quality Program Plan describes the Quality Program to be undertaken by the General Electric Company Space Systems in the fulfillment of its ERTS Phase D Contract with the National Aeronautics and Space Administration, Goddard Space Flight Center. This Plan meets the intent of the Customer's Work Statement and NASA Quality Assurance Publication NHB 5300.4 (1B). The quality program is designed to provide effective controls which will result in contractually compliant end items in all phases of the contract from customer specifications through design, procurement, manufacture, test and flight operations. The Quality Assurance Tasks for each component on the ERTS Program are defined in Tables 5-1, 5-2, 5-3, 5-4, 7-1, 7-2, 7-3, and Appendix E of this plan.

2.1.2 RELATION TO OTHER CONTRACT REQUIREMENTS

This plan and the Space Systems Quality Asurance Procedures Manual constitute the plans and procedures for the Quality Assurance portion of the Quality Tasks of the forementioned Work Statement. An integrated Reliability Program Plan shall define the Reliability tasks as defined by NASA Reliability Publication NPC 250-1.

The Quality Assurance Plan will embody all the quality-related specifications and documents negotiated in the contract as being applicable to the ERTS Program. And changes made to the Quality Program Plan due to Program redirection or interpretation will be submitted for customer approval. These revisions will be made by the ERTS Performance Assurance Manager of Product Assurance and the revisions will be submitted through the Program Office to the customer within thirty (30) days.

The Quality Assurance Procedures (referenced) in this plan are designed as an implementation mechanism. They have been built up over 10 years of spacecraft experience and over 14 years of reentry vehicle experience. These procedures were developed to meet the requirements of NASA and USAF Quality Documents, and include the areas of Quality Program Management, Program Planning and Documentation, Pre-production and Development Quality Activities, Control of Procurements and Handling of Government-Furnished Equipment and Property, Quality Assurance of Fabricated Materials, and Control of Non-conforming Materials, Test and Performance Verification Requirements, Design, Fabrication, and Checkout and Control of Bench Test Equipment and Aerospace Ground Equipment, Quality Training and Certification, Use of Statistical Quality Programming and Handling, Storage and Delivery of Materials. In each of these areas, the procedures are available for review with the customer representatives to ensure that program requirements are met. In cases where new procedures are required, they are generated and submitted for review.

The Quality Program Management team has built up many years of experience in the areas of Quality Assurance. The inspection and test capability has been expanded from the support of Mark 2, Mark 3, and Mark 6, and Mark 12 reentry vehicles through Experimental Reentry Vehicle Programs, and from Discoverer and Biosatellite Orbiting Vehicles through Nimbus and OAO Spacecraft.

This Quality Program Plan has been formatted using the same paragraph number for all subjects as given in NASA NHB 5300.4 (1B). In addition to the individual paragraph reference to applicable Quality Assurance Procedures, a summary cross-reference index of Quality Assurance Procedures, and their applicability to appropriate paragraphs of NHB 5300.4 (1B) and the Quality Program Plan is shown in Appendix A. (These procedures are applicable to ERTS and are identified as Appendix B. Two copies are being submitted under separate cover as supporting documentation.)

2.1.3 ACTIONS AND PREROGATIVES OF THE GOVERNMENT

GE will provide support for the evaluations, review, audit, survey and inspection by NASA-GSFC and its designated quality representatives in accordance with negotiated agreements. Government monitoring of in-process inspections and tests shall be negotiated with the government quality representatives.

Tests and inspections shall be performed in accordance with government reviewed/and/or approved inspection and test procedures. The Government representatives shall be notified in advance for critical/mandatory inspection and test operations in accordance with recognized program flow and schedules.

2.1.4 QUALITY PROGRAM DOCUMENTS

The quality documentation which is to be used in support of Phase "D" is shown in Table 2-1 and is in conformance with the requirements of NHB 5300.4 (1B). It will be submitted for NASA approval, review, and information as shown in the table.

TABLE 2-1. QUALITY PROGRAM DOCUMENT CROSS REFERENCE INDEX (Sheet 1 of 4)

Title	Issue Frequency	First Issue	Customer Required Action
Qualification Status List	As required	30 days after Phase D Start	Approval of 1st Issue Review of Subsequent
End Item Test Procedures (Subsystem and System Test Procedures)	As required	30 days before Test of Flight Spacecraft	Approval of 1st Issue. Verbal approval within 48 hours and subsequent review to allow testing to proceed
End Item Inspection Procedures	As required	30 days prior to Insp. of Flight Spacecraft	Approval of First Issue Verbal approval within 48 hours and subsequent review to allow testing to proceed
Quality Program Plan	Once plus Revision as required	45 days from receipt of comments on preliminary	Approval
Inspection Planning (Inspection Procedures)	As required	Before start of Fabrication	Review on Request
Standing Instructions (Test Procedures)	As required	Before start of Test	Review on Request
Manufacturing Standing Instructions (Process Control Procedures)	As required	Before start of Manufacturing	Review on Request

TABLE 2-1. QUALITY PROGRAM DOCUMENT CROSS REFERENCE INDEX (Sheet 2 of 4)

Title	Issue Frequency	First Issue	Customer Required Action
Results of Special Measuring and Test Equipment Evaluations	As Required	Before start of Test	Review on Request
Storage Procedures for End Items	As Required	Before Use	Review
Special Sampling Plans	As Required	Before Use	Review
Quality Audit Reports	Procedure Compliance-Random Product Quality Verification - Random Major Subcontract Quality Assurance Audits - Random	Before hardware	Available for Information
TE Operating Instructions	As equipments are built	BTE Fabrication	Available for Information
Test Equip. (TE) Calibration Procedures	As required	Initial BTE Calibration	Available for Information
Failure Summary Report	Quarterly	At beginning of Prototype Testing	Review

TABLE 2-1. QUALITY PROGRAM DOCUMENT CROSS REFERENCE INDEX (Sheet 3 of 4)

Title	Issue Frequency	First Issue	Customer Required Action
Supplier Quality Assurance Provisions (QAP's)	As required	Start of procurement	Review on Request
Quality Engr'g Test Requirements	As required	Test equipment procurement	Review on Request
Supplier Survey Reports	During source selection	Start hardware Procurement	Available for Information
Qualified Suppliers List	Quarterly	Start hardware phase	Available for Information
Configuration Verification Listings	At time of shipment	First CEI shipment	Review
Monthly Quality Status Report	Monthly as part of Program Report		Information
Quarterly Audit Summaries of Quality Program Performance	Quarterly		Information
Quality Assurance Procedures	As required	Existing	Information
Approved Parts List	Once plus revisions as required.	Phase D Proposal	Approval
Approved Materials List	Once plus revisions as required	Start hardware design	Approval

TABLE 2-1. QUALITY PROGRAM DOCUMENT REFERENCE INDEX (Sheet 4 of 4)

Title	Issue Frequency	First Issue	Customer Required Action
Failure Analysis Reports	As required		Review
Non-Conformance Reports	As required		Review
Equipment Logs	As required	Completion of component test	Review
Qualification Test Reports	As required	Completion of qualification tests	Review

2.2 QUALITY PROGRAM MANAGEMENT AND PLANNING

2.2.1 GENERAL

Space Systems is currently operating under a quality control system that satisfies the requirements of NHB 5300.4 (1B), Quality Program Provisions for Aeronautical and Space System Contractors. The Quality Program that will be used to support the Phase D activities is designed to control product quality from initiation of design, through production and test, and finally through field operations (See Figure 2-1). The program is implemented by adherence to Space Division Policies and Instructions and Quality Assurance Procedures.

Product Assurance program planning required for the ERTS Program will be initiated by the ERTS Performance Assurance Manager. Product Assurance Plans will be continuously updated to reflect program changes as they occur and will provide current and up-to-date information to program participants.

2.2.2 ORGANIZATION

2.2.2.1 Management Concepts

The General Manager of Space Systems has delegated total responsibility for implementation of the quality program to the Manager of Product Assurance, who reports directly to him. Figure 2-2 depicts the Space Systems and Product Assurance organizations.

2.2.2.2 Product Assurance Organization

Product Quality results from the collective efforts of the organizations involved in the design, procurement, fabrication and test of the end items. Each manager involved is responsible to the General Manager for the excellence of his own activities. The ERTS Product Assurance Project Engineer is responsible for assuring implementation of the Quality Program. The Program Information and Direction Flow are shown in Figure 2-3. Key elements of the ERTS Quality Program include:

1. The integration of quality requirements into hardware designs and specifications.
2. Subcontractor and Supplier Quality Control.
3. Quality measurement and evaluation during procurement, manufacturing and assembly cycles.
4. Planning for parts, materials and processes, applications and controls.
5. A closed loop system for prompt failure detection, analysis, reporting, timely corrective action and follow-up.
6. Participation in or conduct of testing from development tests through acceptance tests of prime hardware.

7. Measurement of the status of hardware through evaluation and analysis of performance data.

8. Configuration verification.

9. Utilization of manual and computerized data for retrieval of information for analysis, correlation and dissemination to all users.

10. Traceability on piece parts and materials to the lot numbers; on components, serialization to the component "black box" level for AVE.

Program integration of Product Assurance activities during the ERTS Phase D Contract will be accomplished by the ERTS Performance Assurance Manager, Product Assurance. Each of the operations within Product Assurance is responsible to the GE-SS Manager of Product Assurance for implementation and performance of his own operational effort, schedule, and funding as negotiated with and integrated by the ERTS Performance Assurance Manager.

Product Assurance work direction for the ERTS Phase D Contract is defined by the ERTS Program Manager to the Performance Assurance Manager, Product Assurance. The Performance Assurance Manager will be responsible for interpreting the information and direction provided for the assigned tasks and determining its application to the Product Assurance work scope. Based on this analysis, the Performance Assurance Manager will provide the necessary written direction and program funding instructions to each Product Assurance Operation required to accomplish the assigned task. Continuous integration and monitoring of the performing Operations will be performed by the ERTS Performance Assurance Manager with emphasis directed toward the achievement of quality performance and the maintenance of negotiated costs and schedules.

The management and integration described above provides a single source of responsibility, communications, and direction for the ERTS Phase D Contract, with the Performance Assurance Manager Product Assurance, as the focal point. Figure 1B-3 indicates this direct line of authority and identifies the path of information flow between the Customer and the Product Assurance Operating Functions.

2.2.2.3 Program Control

Management Control of Product Assurance activities for the ERTS Phase D Contract will be based on management decisions derived from factual information provided in the form of management reports. The Management Reporting System currently used by Product Assurance is a closely integrated network of reports published at periodic intervals and directed to different levels of management. This system will be utilized on ERTS, Phase D.

Management review will be through the use of Program Management and Review Charts provided by Performance Assurance. These charts depict program analysis and progress, various operations, work/cost reports, and hardware planning/status reports reflected by a technical evaluation of the performing operations with respect to their assigned responsibilities. The charts prepared will be used for resolution of problem areas, and presentations to the Product Assurance Section Management on a weekly basis. The presentations will provide Product Assurance management with a continuous appraisal of program information particularly in the area of work/cost analysis, hardware and schedule performance and provide a

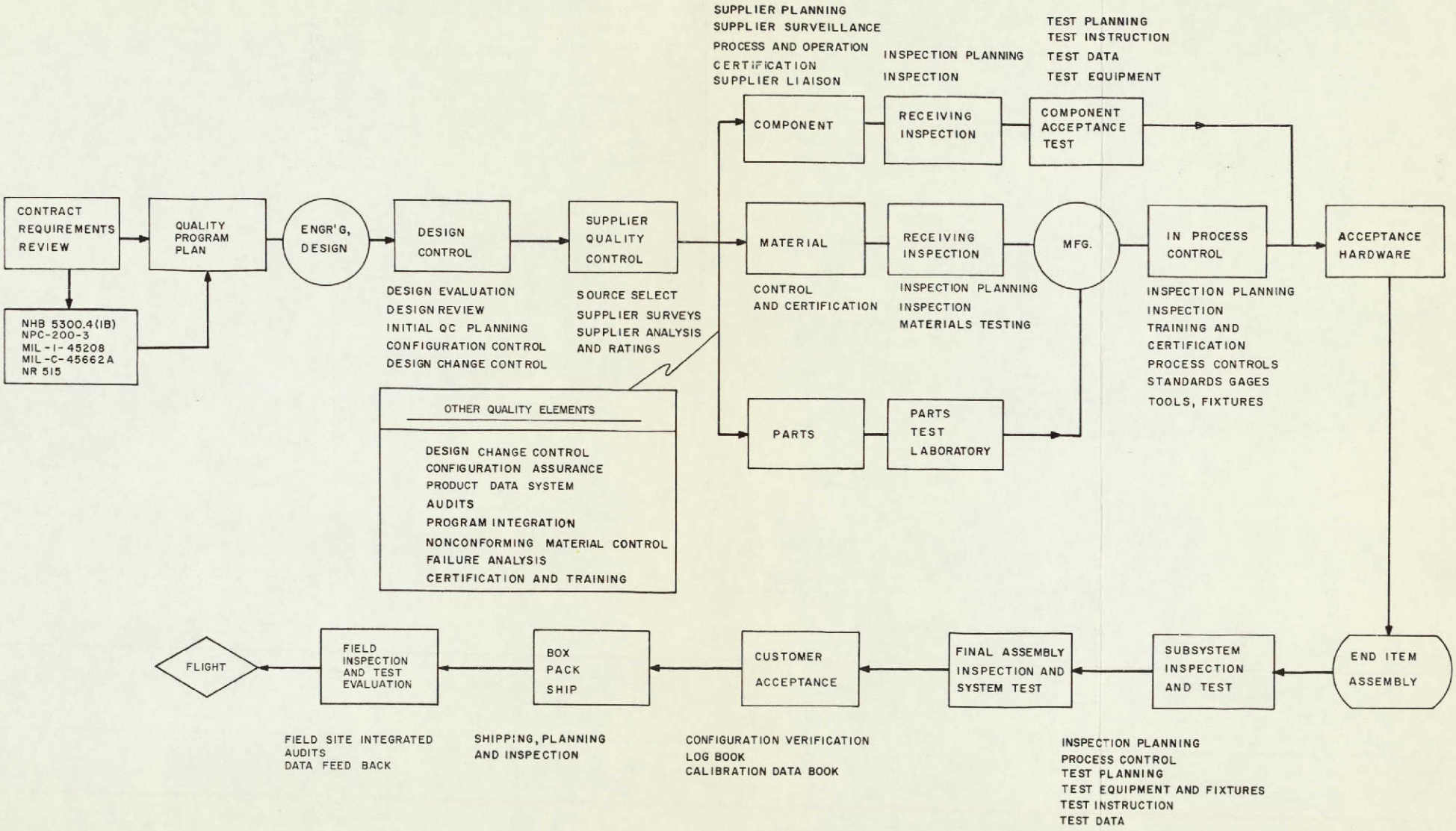

Figure 2-1. Typical Quality Work Elements

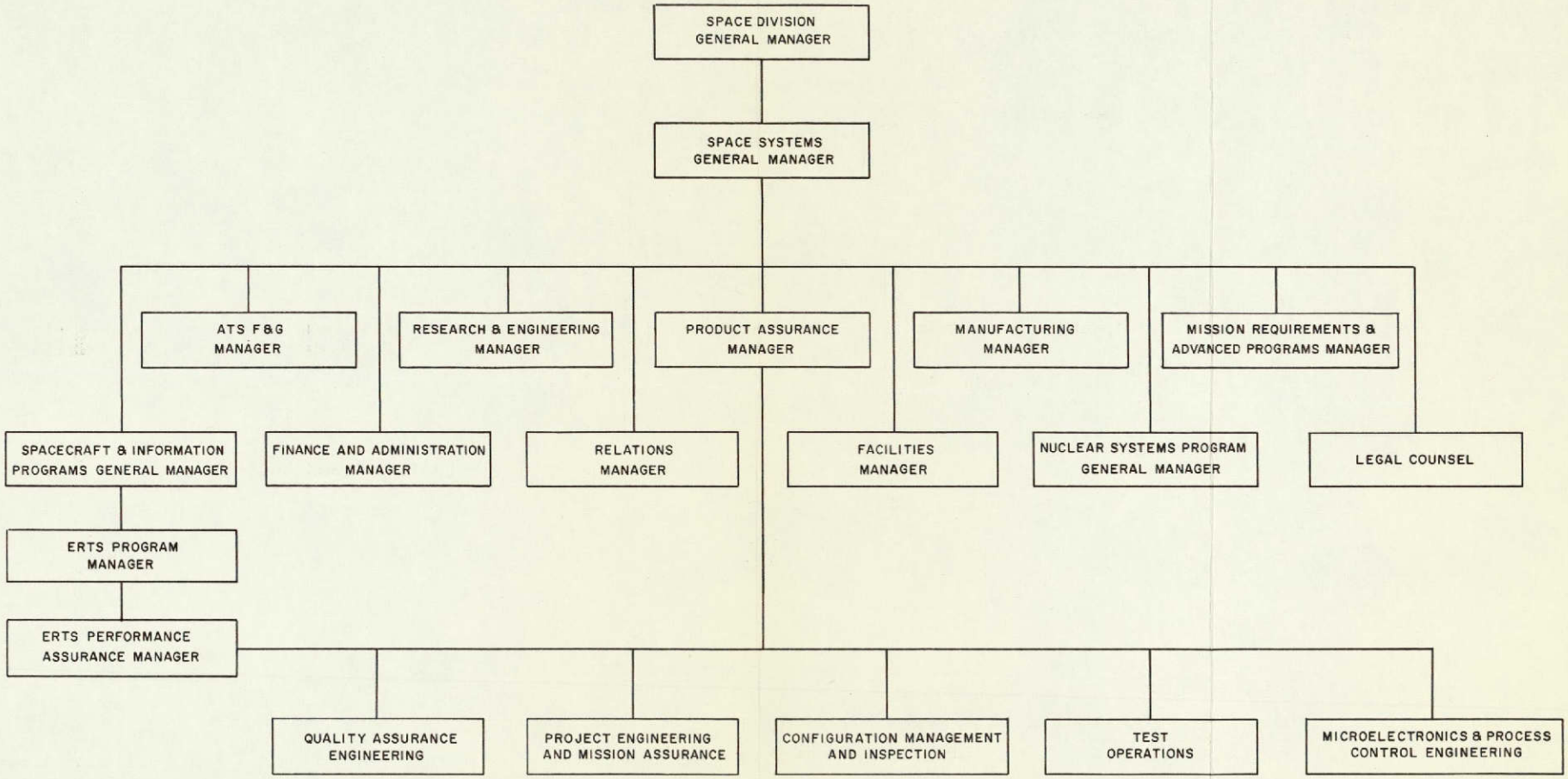

Figure 2-2. Space Systems and Product Assurance Organization

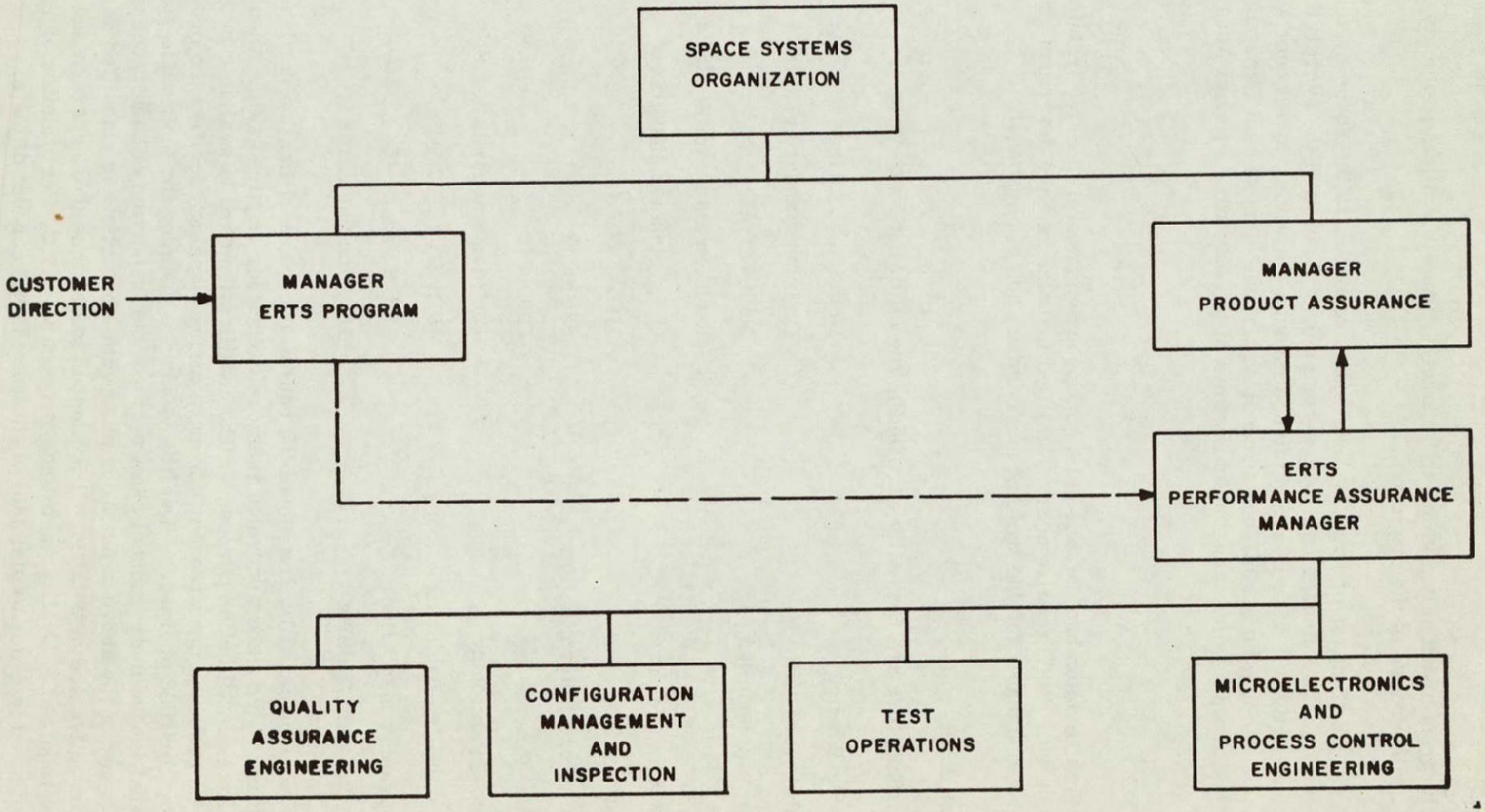

Figure 2-3. Program Information and Direction Flow

method by which direct and timely action can be taken to resolve critical problems that may arise during the course of the program.

In addition, the GE-SS Manager of Product Assurance, reporting to the Space Systems General Manager, provides top management with a complete evaluation of the overall ERTS Product Assurance activity. This is accomplished through the review of Product Assurance management reports using the established Product Assurance Management Reporting System, and conducting his own periodic management reviews of the operating Product Assurance elements.

2.2.3 TRAINING

The Space Systems Division has established a continuous and comprehensive training program that is consistent with ERTS requirements. Qualified instructors have developed course material and unique techniques for the training and certification of personnel.

2.2.3.1 Certification

Operators and Inspectors are currently certified in the following processes:

1.	Adhesive Bonding	Division Standards & MSI's
2.	Painting	Division Standards & MSI's
3.	Penetrant Inspection	MIL-410-A
4.	Potting	Division Standards & MSI's
5.	Cross Wire Welding	G. E. Standard S30002AB
6.	Fusion Welding	MIL-T 5021C
7.	Particle Size Determination	S3000042
8.	Harness Processing	S3000042
9.	Surface Conditioning	Division Standards & MSI's
10.	Hi-Reliability, Soldering	NHB 5300.4 (3.A)
11.	Radiographic Inspection	MIL Standard 453
12.	Electron Beam Welding	Division Standards

Personnel who have successfully completed the course receive certification cards and are placed on a listing. This listing provides ready reference for required skills when needed and offers control for recertification purposes. The certification card is available in the work area and must be produced upon request. Manufacturing planning specifies the processes to be performed by certified operators. Quality Assurance planning for the article specifies that only certified inspection personnel shall perform the inspection of such processes. In the event that either of the above are not complied with, the article is classified as nonconforming and corrective action is taken. It is planned to continue those courses and institute new courses as required. Quality Assurance Procedure 13.2, Certification of Test Conductors, will be followed in order to maintain proficiency in the conduct of tests.

2.2.3.2 Recertification of Personnel

The General Electric Company has developed a statistical approach to assure skill retention by the operator or inspector. A period of one year is used as the basis for recertification and is dependent upon:

1. The number of persons that either pass or fail the recertification test.
2. The number of nonconformances that occur on a specific process.

2.2.3.3 Certification Recall

Certified personnel shall maintain their certification status until:

1. The quality performance of the operator or inspector becomes suspect.
2. The operator or inspector fails the recertification test.
3. The operator or inspector is transferred to another area.
4. The certification time period has elapsed.

Process Control Engineering will bring to the attention of the area supervisor those processes that have a high nonconformance rating. If the cause is traced to the operator, the certification card will be recalled from that operator.

When the operator's card has expired or he is transferred to another work area not requiring certification status, the cognizant manager will retrieve the certification card. A procedure is in place for notification of personnel for recertification.

2.2.4 QUALITY INFORMATION

Product Assurance has developed and will utilize a Product Data Center (PDC) for the ERTS Program that will assure:

1. Establishment of an integrated system approach to the accumulation of performance data.
2. Maintenance of performance data control throughout the integrated reporting system.
3. Accumulation and processing of empirical data for feedback, analyses and action.
4. Identification of quality and reliability problems, and near real-time data presentation for review, analyses and implementation of effective corrective action and follow-up.

5. Traceability to validate the reliability and quality integrity at required levels of the product to assure conformance to design specification, permit failure analysis to the level required and to locate suspect hardware for corrective action.

The Product Data Center (PDC) will support the ERTS Program with data processing, data storage, and data retrieval support in the functional areas of hardware configuration and traceability, hardware nonconformances, hardware performance information, and buy-off documentation.

2.2.5 QUALITY STATUS REPORTING

Product Assurance will provide a monthly quality status report, as part of the Monthly Progress Report, that will provide a summary of quality activity for the reporting period and will identigy:

1. Significant quality accomplishments
2. Quality documents submitted for approval, review, or information
3. Requested changes to approved quality documents
4. Quality problems requiring resolustion by NASA-GSFC

2.2.6 QUALITY PROGRAM AUDITS

Periodic scheduled audits will be conducted to assess and evaluate the effectiveness of controls in GE-SS affecting quality and to analyze and evaluate the level of product quality. These audits will also be conducted in the supplier's plants, in-house and in the field. Nonconformances will be made known to cognizant levels of management and corrective action requested with defined completion dates.

Upon completion of each audit, an audit report will be prepared including the indicated corrective action, and will be distributed to the responsible management. Audit summary reports will be submitted to the NASA Contracting Officer for information.

Follow-up audits will be conducted on the deficient areas until these conditions have been corrected.

The types of audits scheduled to be performed are:

1. Procedure Compliance
2. Product Quality Verification
3. Major Subcontract Quality Assurance Audits including MRB Delegation.

2.2.7 QUALITY PROGRAM PLAN

This Quality Program Plan defines the quality program and contractual quality requirements for the execution of the specific terms and conditions of the contract. It will be coordinated with the Master Program Schedule and will be used during the course of the contract to set the guidelines and direction for the Product Assurance Section.

The Quality Program Plan will be kept current and will incorporate changes as they are required.

2.2.7.1 Quality Program Plan Changes

All changes to this plan will be accomplished through the use of Product Assurance Project Engineering Memos. All revisions, deletions or additions to the plan shall be submitted to NASA/GSFC for approval.

2.2.7.2 Operating Procedures

The documentation used for the ERTS Quality System consists of an integrated package of procedures (Quality Assurance Procedures); these are instructions and plans which incorporate the customer requirements into clearly defined criteria for the performance of all work functions. Figure 2-4 depicts the use and flow of Quality Assurance documentation.

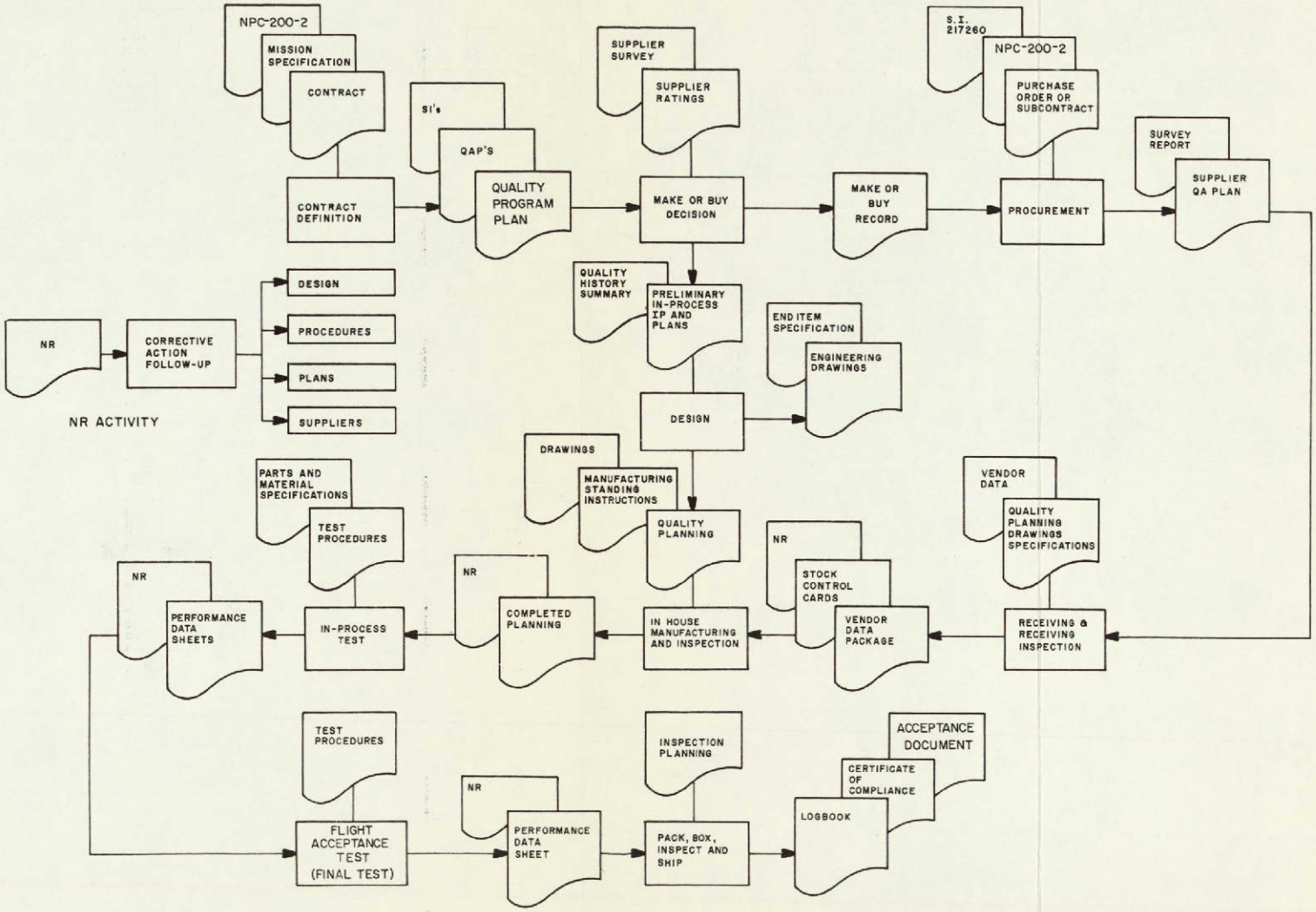

Figure 2-4. Product Assurance Documentation Tree

2.3 DESIGN AND DEVELOPMENT CONTROL

2.3.1 TECHNICAL DOCUMENTS

The method being employed by GE-Space Systems for ensuring that product quality is a major consideration in hardware manufacture, design, and development is the ensurance that all program documentation and requirements reflect the statement of work and appropriate interface requirements. In order to ensure this, the ERTS Product Assurance Project Engineer reviews all interface agreements and provides inputs to the GE-SS interface representative on characteristics determined to influence product quality on drawings, specifications, and test procedures.

Interface documentation will be maintained and controlled on the ERTS Program in agreement with NASA-GSFC.

During Phase B/C, Product Assurance participated in, and will continue to participate in, the following areas:

1. Review specifications and drawings
2. Define test equipment requirements
3. Establish flow diagrams (inspection and test)
4. Establish inspection and test requirements
5. Participate in design reviews
6. Design, fabrication, and checkout of bench test equipment
7. Review of process and fabrication specifications
8. Participate in electronic module fabrication processes
9. Participate in unique training programs
10. Define parts application
11. Develop approved parts list
12. Develop approved materials/process lists
13. Preparation of configuration control plans
14. Implementation of a change control board
15. Perform in-house and supplier quality audits
16. Quality evaluation of suppliers and subcontractors
17. MRB delegation

Specifications and test procedures will be reviewed, before implementation, for qualification and acceptance testing to ensure inclusion of (at least) the following:

1. Test objectives
2. Adequacy of test to determine test objectives
3. Definition of performance and acceptance criteria
4. Unique test equipment and environment

Drawing and specifications will be reviewed to ensure compliance with the following quality requirements:

1. Item identification
2. Configuration identification
3. Adequacy of MIL STD's and/or process specifications
4. Special requirements

Process specifications will be generated to identify and define any new processes used on the program. All existing process specifications are reviewed and updated as required. These specifications contain (at least) the following:

1. Description of process
2. Certification of requirements
3. Process performance and acceptance criteria
4. Adequacy of process to ensure provisions of quality
5. Process stability and uniformity

Procurement documents will be reviewed by Product Assurance to ensure the inclusion of applicable quality requirements.

2.3.1.1 Bench Test Equipment and AGE

The methods to be utilized in ensuring that product quality is a major consideration during the design and development of the BTE and AGE will be that of a Quality Engineer reviewing the BTE and AGE designs periodically throughout the design cycle. The Quality Engineer will review the design drawings to ensure that adequate requirements are contained for determining and controlling quality of the items purchased or produced. The Quality Engineer will also assist the BTE and AGE Design Engineers in defining which items must be inspected and types of inspection to be performed. Informal design reviews will be performed on BTE and AGE.

2.3.2 QUALITY SUPPORT TO DESIGN REVIEW

Product Assurance personnel will participate in ERTS Program design reviews on newly designed or modified hardware to ensure that specifications and drawings contain adequate quality requirements. Potential quality problems will be recognized, and information relative to quality, possible test methods, and producibility will be discussed during the design review sessions. The design reviews will be documented and will be available to NASA personnel.

2.3.3 CHANGE CONTROL

Documentation affecting the ERTS Product Assurance Program is controlled to ensure that only the latest applicable instructions are followed and/or incorporated into the ERTS Program.

Program changes and/or redirections are issued by the ERTS Program Office in the form of Program Directives. The Product Assurance Project Engineer is on distribution for all Program Directives. Product Assurance Project Engineering Memorandums (PAPE Memos) are issued to define the implementation of Program Directives affecting product quality; a PAPE memo is required for Product Assurance response to ERTS Program Directives.

Changes to GE-SS designed and fabricated Bench Test Equipment (BTE) and AGE are not controlled via the formal design change function. Product Assurance Project Engineering is made aware of changes to BTE and AGE by being on distribution for all such changes, in order that they may be incorporated into test and checkout procedures.

The configuration baseline for the GE-SS fabricated BTE and AGE will be established after completion of ERTS Bench Integration Testing. All drawings and procedures at this time will reflect the status of the BTE and AGE and its compatibility with the vehicle. All changes made after the configuration baseline is established will be via the Engineering Change Proposal (ECP) routine. Product Assurance Inspection will ensure that all changes incorporated into the equipment are documented and recorded.

Drawing changes will be controlled as defined in Configuration Control Plan and Quality Assurance Procedures (Section 2.2 "Drawing, Specification, Instruction and Change Control" and Section 2.3 "Configuration Assurance Program").

Drawing specifications, standing instructions, planning, and other documentation defining quality will be delivered directly to the inspection and/or test areas and monitored by an operations control function to ensure that up-to-date requirements are being factored into working documentation.

Changes to inspection and test procedures are controlled as described in Quality Assurance Procedures (Section 6.1 "Fabricated Prime Equipment, Planning and Inspection of," Section 6.2 "Quality Assurance of Manufacturing Standing Instructions," and Section 6.3 "Component Standing Instructions"). The inspection planning is integrated with the manufacturing planning and has a cover sheet that contains the change status. This cover sheet lists the latest change notice which the planning satisfies and; the manufacturing and quality planners initial the status.

Responsibility for detailed component test procedures is assigned to the Quality Control Engineer; he incorporates changes into these Standing Instructions (SI's) as required to maintain them current. The Quality Control Engineer is also responsible for reviewing all test data and the signing of data sheets.

Configuration Management requirements for ERTS subcontractors are identical to those defined in the General Electric (Prime) Configuration Management Plan, CMO 158, with the exception that General Electric will perform the initial review function for the Engineering Charge Proposal (ECP's) through the General Electric ERTS CCB. GE CCB-approved changes shall be forwarded to GSFC ERTS CCB for official approval prior to implementation.

2.4 IDENTIFICATION AND DATA RETRIEVAL

2.4.1 GENERAL

General Electric has established a system to permit identification, verification, and retrieval of data to provide for location of procured and fabricated hardware. This system utilizes the engineering design release documentation in conjunction with manufacturing fabrication and quality inspection planning and configuration verification records.

2.4.2 IDENTIFICATION METHODS

General Electric Space Systems will serialize "black boxes", subsystems, and systems for which a functional or performance test is conducted. These serialization requirements will be incorporated in procurement documents for major subcontractors and suppliers and will be performed in accordance with Space Systems Instruction 4.23, "General Electric Serial Numbers."

Electronic piece-parts will be identified on the basis of lot procurement and acceptance. Data reflecting the lot number will be maintained in the parts laboratory.

Other articles, such as rivets, and standard stock will not be identified beyond the point of their initial acceptance and incorporation into bonded stock.

Inspection status is shown as defined in Quality Assurance Procedure 6.11.

2.4.3 DOCUMENTATION

Engineering drawings will be prepared in accordance with the requirements of GE-MSD Drafting Standards, Number 702, Book 1, and the drawings, associated lists, and parts shown thereon will be so identified.

2.4.4 IDENTIFICATION CONTROL

Products and critical processes on the ERTS Program will be derived from, and shall be traceable to, engineering documentation (approved specifications and drawings).

2.4.5 IDENTIFICATION LIST

Data processing cards prepared from the latest engineering released design information will be used by In-Process Inspection, where verification entries will be made by Product Assurance Inspectors as components and assemblies are inspected. At the same time, serial numbers of black boxes and higher level assemblies will be recorded, thus providing the data base for traceability data. These "verified" cards will be used for producing "as-built" and "as-designed" configuration lists.

2.4.6 RETRIEVAL OF RECORDS

GE-SS has established procedures as referenced below for the collection and analysis of quality data. This data includes inspection/test results, failures, non-conforming materials, vendor and in-house shop measurements.

The following is a summary of the quality information that will be generated on the ERTS Program and the methods that will be employed by Product Assurance in the handling control, and retention of this information.

Item	Control/Retention Effort
1. Travel Tags	
a. Purchased hardware	
(1) Serial-numbered items	Travel tag will be attached to unit at Receiving Inspection until receipt at Configuration Control and/or Final Assembly and then removed and filed in Configuration Control area by drawing number.
(2) Non-serial-numbered items	Travel tag will be attached to units at Receiving Inspection and will accompany hardware to bonded stock. If travel tags accompany hardware to toll gate, it will be removed and filed by drawing number in the Configuration Control area.
b. In-house Fabrications	
(1) Serial-numbered items	Travel tag will be attached to unit at beginning of fabrication and remains with unit until receipt at Configuration Control and/or Final Assembly and then removed and filed in Configuration Control area by drawing number.
(2) Non-serial numbered items	Travel tag will be attached to unit(s) at beginning of fabrication and will accompany hardware to bonded stock. If travel tag accompanies hardware to toll gate, it will be removed and filed by drawing number in the Configuration Control area.

Item	Control/Retention Effort
2. Acceptance Data	Upon completion of Acceptance Test, and approval of the data by Quality Control Engineering, test data is forwarded to Configuration Control to be filed by nomenclature and serial number.
3. Vendor Data	After data has been approved by Quality Control Engineering, Receiving Inspection will forward to Configuration Control area to be filed by drawing number.
4. GFE	
a. Contractor data	Accompanies hardware to bench acceptance test area; upon completion of test, data is forwarded to Configuration Control to be filed by GFE nomenclature and serial number.
b. Bench acceptance data	Upon completion of bench acceptance, test data (Engineering Test Report) is forwarded to Configuration Control to be filed by GFE nomenclature and serial number.
c. Travel tag	Remains with material until receipt at toll gate when it is removed and filed by Configuration Control by vehicle. (At this time, the data referenced in a and b above is transferred to the specific vehicle data file.)
5. Manufacturing/Inspection Planning (Completed)	
a. Components and harness	Removed from the components and harness when completed and ready for bonded stock and filed by Configuration Control by drawing number.
b. Final assembly planning	Filed by vehicle in Configuration Control when the assembly operations/inspections are completed.
6. Inspection Reports (Closed)	
a. Serial-numbered hardware	Filed in Configuration Control area by drawing number and serial number with other quality information.
b. Non-serial-numbered hardware	Filed in Configuration Control area by NR number.

Item		Control/Retention Effort
7.	GSFC Malfunction Reports	Both closed and open reports will be filed by Product Assurance Reliability Analysis Engineering.
8.	Systems Test Data Sheets	Raw data will be kept on file by vehicle by Configuration Control. Reporduced copies will be supplied to Systems Test personnel for analysis, report writing, etc.
9.	Auxiliary Systems Test Data (Photos, Magnetic Tape, Brush Recordings, etc.)	Retained in Systems Test Data Center.
10.	Connector Mate/Demate Logs	Maintained in vehicle work books accompanying vehicle by In-process Quality Assurance (IPQA).
11.	Component Operating Times (Systems Test)	Maintained in vehicle work books accompanying vehicle by IPQA.
12.	Break of Inspection Records	Maintained in vehicle work books accompanying vehicle by IPQA.
13.	AN Control Records	Maintained in vehicle work books accompanying vehicle by IPQA.
14.	Weights Control Sheets	Maintained in vehicle work books accompanying vehicle by IPQA.
15.	Significant Event Log	Maintained in vehicle work books accompanying vehicle by IPQA.
16.	Failure Reports (Systems Test)	Open copies will be retained in vehicle work book until closed bopy is received from Failure Analysis Engineering; and this then would replace the open copy in the vehicle work book.

2.5 PROCUREMENT CONTROLS

2.5.1 GENERAL

Product Assurance has the responsibility to assure adequate quality control of procured items starting with the selection of qualified sources and continuing until a quality product is accepted into bonded stock (Figure 2.5-1). The control of procured articles will be in accordance with Space Systems Quality Assurance Procedures and in conformance with NHB 5300.4 (1B). Pre-award surveys, conferences, source surveillance and quality audits will be employed to insure subcontractor and supplier compliance with contract provisions.

Volume 1 of this study report lists the components to be procured by General Electric. "Quality Plan for Earth Resources Technology Satellite A&B Subcontract," GE Document Number 69SD4379, outlines the Quality System and requirements imposed on each of General Electric Major Subcontractors.

2.5.2 SELECTION OF CONTRACTOR PROCUREMENT SOURCES

General Electric has established a system which ensures that procurement sources are evaluated and approved, as required, prior to issuance of the purchase order or subcontract. A quality evaluation will be performed as indicated on Table 2.5-4.

Use of qualified suppliers will be in accordance with Quality Assurance Procedure 4.1 "Supplier Survey/Selection". Quality approval will be based upon a review of the supplier's quality history, or the results of a survey report. Prior to award, selected suppliers must satisfy one of the following conditions:

1. Have a quality record of supplying high quality articles of the type being procured. The quality data, accumulated and analyzed by Product Assurance, will be in the form of qualitative and quantitative information based on objective evidence and will be documented in a Qualified Vendor's List.
2. If no up-to-date rating is available, a survey of the supplier's facilities and quality control system will be accomplished. The survey must indicate that the supplier has the capability to supply articles which meet all quality requirements. The supplier's system for controlling hardware quality, methods for measuring achieved hardware quality, test and inspection capability, handling methods and other factors influencing quality will be evaluated.

When commercial or "off-the-shelf" items are to be procured and no quality history on the supplier is available, the decision to conduct a survey will be based upon the following considerations:

1. End use of the item (criticality)
2. The probability of latent defects. Are defects detectable by Receiving Inspection or subsequent test
3. Procurement Lead time

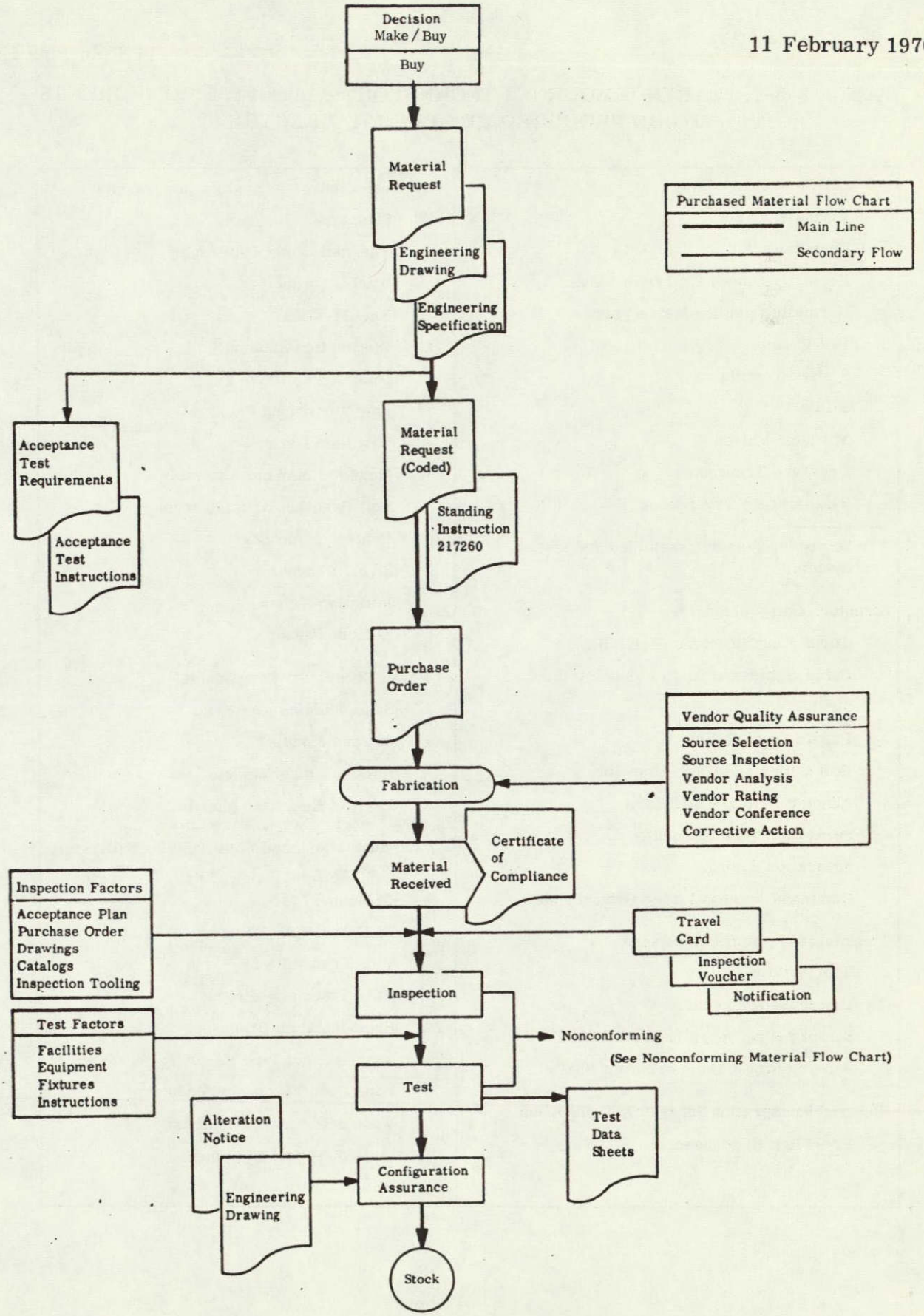

Figure 2.5-1. Purchased Material Flow Chart

TABLE 2.5-1. EARTH RESOURCES TECHNOLOGY SATELLITE COMPONENTS TO BE PROCURED BY GENERAL ELECTRIC

*Orbit Adjust Subsystem
- Propellant Tank
- Thrusters
- Normally Closed Explosive Valve
- Normally Open Explosive Valve
- Fill Valves
- System Test Valve
- Filter
- Thruster Valves
- Pressure Transducer
- Temperature Transducer

*To be procured as an assembled and tested subsystem.

Structure Components
- Torus Ring Structure (Partial)
- Cable Cutter and Squib Assembly
- Struts
- Paddle Latch Cable
- Bolt Cutter and Squib Assembly
- Adapter Primary Structure
- Separation Band Assembly
- Separation Springs
- Command Antenna Lower Ground Plane

Thermal Subsystem Components
- Thermistors
- Compensating Loads
- Sensory Ring Upper Insulation Shells
- Sensory Ring Lower Insulation Shells

Electrical Integration Subsystem Components
- Pre-Flight Disconnect

Attitude Control Subsystem Components
- Structure
- Thermal Control Assembly
- Pitch Flywheel
- Yaw Flywheel
- Pneumatics Assembly
- Solar Array Drive
- Rate Measuring Package
- Yaw Rate Gyro
- Magnetic Moment Assembly
- Roll Reaction Wheel Scanner
- Control Logic Box
- Signal Processor
- Initiation Timer
- Attitude Sensor

Power Subsystem Components
- Solar Paddles
- Storage Modules
- Power Control Module
- Payload Regulator Module

Communications and Data Handling Subsystem Components
- Command Clock
- VHF Command Receiver
- VHF Transmitter
- PCM Telemetry Processor
- Premodulation Processor
- Narrow Band Tape Recorder
- Wide Band Frequency Modulator
- Wide Band Power Amplifier
- Unified S-Band Equipment
- Filter

Both pre- and post-award surveys are conducted by General Electric in accordance with established survey procedures. At the conclusion of a pre-award source survey, the supplier's inherent capabilities and limitations will be appraised. The supplier will receive a quality rating: acceptable, conditional, or unacceptable. In the event the contract is awarded to a supplier with a conditional rating, the quality deficiencies will be incorporated into the contract with specified corrective action to be taken within a prescribed time period. Subsequent follow-up audits will determine the fulfillment of contract commitments.

2.5.3 PROCUREMENT DOCUMENTS

Procurement documents will be initially reviewed as early as possible in the procurement cycle by Quality Engineering, but no later than the Material Request (MR) level. This form is initiated for the procurement of any Program material or service.

Material Requests are coded for the type of inspection, test, and routing to be accomplished upon receipt in-house. The initial review of MR's is the point at which a determination is made of the information or requirements to be specified for a particular procurement.

Between review of the MR and the actual release of the documents for procurement additional steps are taken. For competitive bids, Request for Quotes will be issued. In cases where suppliers take exception to, or do not clearly understand the quality provisions, or propose alternate methods, GE Procurement Operations will make use of pre-award conferences to obtain clear and mutual understanding and to insure that the supplier is willing and able to comply. Close personal supplier contact prevents potential problems resulting from misunderstanding or misinterpretation of specifications. The pre-award conferences will be documented by conference minutes containing the "Action Items" with established completion dates for the required corrective action.

Quality requirements for items where quality definition is not definitive on drawings or specifications, or where testing and vendor surveillance is to be performed are documented in Quality Assurance Provisions (QAP). QAP's are prepared in accordance with Quality Assurance Procedure 4.6 "Supplier Quality Assurance provisions". These are incorporated into and become a part of the Procurement Requirements Document. Quality requirements for the remaining hardware categories will be established by incorporation into the procurement document of the applicable Quality requirements.

Subcontracts and purchase orders issued will contain provision for the following as applicable:

1. Engineering Specification - Will be referenced on the Purchase Order or Subcontract and will become part of the procurement package. The Specification will delineate design and test requirements for the article.
2. Quality Assurance Provisions - "Quality Plan for Earth Resources Technology Satellite A&B Subcontracts" GE Document #69SD4375 NHB 5300.4 (1B) (or NPC-200-3) provide the basic requirements.
3. Government Source Inspection Requirements - When Government Source Inspection is required, a statement to that effect will be included.

4. General Electric Source Inspection - When the need for GE Source Inspection has been determined, the requirements will be detailed in subcontracts and purchase orders.

5. Other Requirements defined in Purchase Order are:

   a. Purchased raw material controls

   b. Control of raw materials used in purchased articles

   c. Evidence of supplier inspections performed

   d. Identification, preservation and packaging

   e. Shelf Life Control

   f. Material Review Board

   g. Re-submission of rejected material

   h. Cleanliness and contamination requirements

   i. Articles of Supplier design (control of supplier's changes in design, fabrication method, or process)

   j. Process Controls

Procurement documents will be controlled as defined in Quality Assurance Procedure 4.2 "Procurement Documents - Quality Requirements".

2.5.4 CONTRACTOR QUALITY ASSURANCE PERSONNEL AT SOURCE

Inspection at source or objective evidence that the supplier complies in detail with the procurement requirements will be required by GE for the respective procurements when Receiving Inspection cannot verify the quality of the articles because of one of the following:

1. The articles being procured are at a level of assembly which prevents verification of quality

2. In-process controls have such an effect on the quality of the articles that the quality cannot be determined by inspection or test of the completed article

3. Verification tests are destructive in nature or the environmental or special test equipment required cannot be feasible or economically reproduced or made available at Receiving Inspection

4. That it is expedient to check an item in process of fabrication, assembly, or testing

5. That the item is to be conditionally accepted at source

6. Whenever it is more economical to conduct inspection at source

Product Assurance representatives will be assigned to supplier's plants to assure the supplier's compliance to his contractual obligation. Tables 2.5-2 and 2.5-3 show the components where source inspection will be provided to witness Acceptance testing and Qualification testing.

TABLE 2.5-2. EARTH RESOURCES TECHNOLOGY SATELLITE COMPONENTS TO BE ACCEPTANCE-TESTED BY SUBCONTRACTOR

Orbit Adjust Subsystem
- Propellant Tank
- Thrusters
- Normally Closed Explosive Valve
- Normally Open Explosive Valve
- Fill Valves
- System Test Valve
- Filter
- Thruster Valves
- Pressure Transducer
- Temperature Transducer

Structure Components
- Thermistors

Electrical Integration Subsystem Components
- Pre-Flight Disconnect

Attitude Control Subsystem Components
- Thermal Control Assembly
- Pitch Flywheel
- Yaw Flywheel
- Pneumatics Assembly
- Solar Array Drive
- Rate Measuring Package
- Yaw Rate Gyro
- Magnetic Moment Assembly
- Roll Reaction Wheel Scanner
- Control Logic Box
- Signal Processor
- Initiation Timer
- Attitude Sensor

Power Subsystem Components
- Solar Paddles
- Storage Modules
- Power Control Module
- Payload Regulator Module

Communications and Data Handling Subsystem Components
- Command Clock
- VHF Command Receiver
- VHF Transmitter
- PCM Telemetry Processor
- Premodulation Processor
- Narrow Band Tape Recorder
- Wide Band Frequency Modulator
- Wide Band Power Amplifier
- Unified S-Band Equipment
- Filter

TABLE 2.5-3. EARTH RESOURCES TECHNOLOGY SATELLITE COMPONENTS REQUIRING QUALIFICATION TEST BY SUBCONTRACTOR

Orbit Adjust Sub-System
- *Propellant Tank
- Thrusters
- Normally Closed Explosive Valve
- Normally Open Explosive Valve
- Fill Valves
- System Test Valve
- Filter
- Thruster Valves
- Pressure Transducer
- Temperature Transducer

*Propellant tank to be qualified as a separate component. Remaining components have been previously qualified to similar environmental levels. Sub-system to be qualified as an assembled unit.

Structure Components
- Cable Cutter and Squib Assembly
- Bolt Cutter and Squib Assembly

} Lot Qualification required for procurement.

Attitude Control Subsystem Components
- Control Logic Box
- Attitude Sensor

Communications and Data Handling Subsystem Components
- VHF Command Receiver
- VHF Transmitter
- Premodulation Processor
- Narrow Band Tape Recorder
- Wide Band Power Amplifier
- Unified S-Band Equipment
- Filter

Supplier surveillance is performed in accordance with Quality Assurance Procedure 4.4.

The representatives will be responsible for assuring the supplier's compliance to his quality plan, for follow-up corrective action, for verifying the adequacy of key manufacturing processes, for performance of in-process inspections, for witnessing and approving acceptance and qualification testing, and for final acceptance prior to shipment.

Detailed supplier quality assurance planning will be developed in accordance with GE-SS Quality Assurance Procedures identifying the points in the manufacturing flow that require inspection, along with the applicable quality acceptance criteria.

Feedback data will be identified to the particular item and become a part of the historical data package on the item.

2.5.5 GOVERNMENT SOURCE INSPECTION

The need for Government Source Inspection will be determined by NASA/GSFC or its designated representative. When Government Source Inspection is required, purchase orders will contain statements, as applicable. Proper application will be in accordance with Quality Assurance Procedure 4.3 "Government Source Inspection".

2.5.6 RECEIVING INSPECTION SYSTEM

The Product Assurance Receiving Inspection function verifies the compliance of purchased material to the purchase order. This is accomplished through the use of approved inspection and test procedures and in accordance with Quality Assurance Procedure 4.5 "Receiving Inspection - General". The Earth Resources Technology Satellite Quality Inspection Planner reviews all Material Requests (MR's) prior to issuance of the purchase order for determining the type of receiving inspection to which the items will be subjected upon receipt.

Inspection coding on the purchase order or subcontract prescribes the level of inspection and test to be performed and the area in which the work will be accomplished. The extent of the inspection varies from:

1. Inspect to drawings and specification
2. Perform sampling inspection in accordance with MIL-STD-105D
3. Inspect to detailed inspection planning

Specific Receiving inspection and test planning will be generated consistent with the engineering design and quality requirements for each particular item. This planning will be reviewed and approved by the cognizant Quality Engineer. In addition to inspection by Receiving Inspection for identification and damage, samples of electrical wire, potting compounds, etc., will be sent to the materials laboratory for physical/chemical analysis. Final acceptance of these items will be based on the materials laboratory analysis. Material acceptance is defined in Quality Assurance Procedure 4.7 "Release of Materials Accepted by Certification and/or Test Results".

Prior to final acceptance, if in-house testing is required, the item will be routed to respective test areas for performance and acceptance tests in accordance with established test procedures.

Identification - Procured items will be identified per receiving inspection planning requirements prior to release to bonded stock as having been accepted.

2.5.6.1 Bonded Stock

General Electric will utilize its established Bonded Stock system on the Earth Resources Technology Satellite Program. All hardware as received will go through receiving inspection into bonded stock or to stock at point of usage. This system provides adequate controls for material upon receipt where such material is not immediately needed for assembly into a component or spacecraft. Where the material is to be used for immediate fabrication or assembly, defined as stock at point of usage, it will be sent to controlled areas (toll gates) in the shop or assembly floor.

General Electric has recognized the need for controlling access to and the use of government-owned material procured for use in the performance of a government contract. In so doing, GE-established procedures will provide for the operation, entry and withdrawal control, segregation by task and program, limited access of personnel, inventory of materials, control of serialized parts and audit and inspection of operation. These applicable procedures will be utilized for Phase D of the Earth Resources Technology Satellite Program.

The following procedures define Bonded Stockroom operation.

Production Support Instructions	
1.0	Material Withdrawal from a Bonded Stockroom
1.1	Receipt of Material in a Bonded Stockroom
1.2	Inventorying of Government-owned Material in Bonded Stockrooms
1.3	Recount Procedure for Bonded Stockrooms
1.5	Authorization for Withdrawal of Material from Bonded Stock

Quality Assurance Procedure	
10.4	Stores Auditing

In addition to these procedures, individual Receiving Inspection Planning will be prepared, summarizing the hardware definition defined in Specifications and Drawings, and applicable Test Instructions and the characteristics required to be inspected in the form of mechanical dimensions, electrical checks or a review for proper paperwork. The performance of

receiving inspection will insure acceptance of all material, parts, and assemblies prior to storage in Space Systems bonded stockrooms or use in fabrication or assembly.

Nonconforming Procured Material - Material found to be nonconforming during receiving inspection will be documented on GE-Space Systems Nonconforming Report (NR) Form and processed per Chapter 8.0 of this Plan.

Failure and Deficiency Feed Back - Suppliers of discrepant material are furnished with copies of all NR's on products they supply. The Product Assurance Corrective Action Specialist continuously monitors vendor quality performance and performs a vendor feed back function as part of his duties.

All Material Requests (MR's) for the purchase of electrical piece parts will be coded by Inspection Planning so that upon receipt the items will be subjected to Receiving Inspection for verification of part type, identification and quantities against purchase order and for physical damage.

Electrical instruments, e.g., oscilloscopes, power supplies, and meters, purchased for use in Earth Resources Technology Satellite BTE and/or AGE will be subjected to the type Receiving Inspection defined in Paragraph above, then will be delivered to the Instrument and Measurements Laboratory for calibration.

All other parts - Verify part type, identification, and quantity against purchase order and inspect for breakage. No other measurements of parameters are to be made unless specified by Engineering to Production Control by Program Information Request/Release (PIR) or autogram. If additional inspection requirements are specified, they are to appear on the purchase order.

If, during the informal design review of the BTE and/or AGE by the Earth Resources Technology Satellite Quality Engineer, specific items to be procured are determined to warrant additional or more elaborate inspections, these inspection requirements will be defined on the Material Request (MR) and/or on receiving inspection planning.

Incoming material that exhibits evidence of GE Source Acceptance and is accompanied by required Inspection and Test Data will be inspected by Receiving Inspection to the extent necessary to identify the item as the item being purchased, verify that no shipping damage has occurred and for completion of the necessary quality documentation. As directed, specific tests or segments of tests shall be completed to assure that the performance characteristics of the item have not been affected by the environments to which the item was subjected during shipment.

2.5.7 RECEIVING RECORDS

GE-Space Systems procedures provide for the identification of all materials at Receiving Inspection. Indication of conformance or rejection is evident on the inspected item. Identification of raw materials by lot shall be carried forward to the planning sheets accompanying the unit. Receiving date shall be retained by the Receiving Inspection Operation.

2.5.8 SUPPLIER RATING SYSTEM

Data is collected to reflect, by drawing number, the results of inspections and tests to which the purchased material is subjected. This data, accumulated from source inspection, receiving inspection, and component test results, is analyzed to determine the causes and responsibilities for the discrepancies or problems encountered. It is then screened, and used to produce supplier quality rating reports. The status of major subcontractor evaluation is defined in Table 2.5-4.

Additional data related to supplier's performance is obtained by searching the contents of the Nonconformance, Performance, and as needed, the Configuration Subsystems files. These files contain details of nonconformances, failures, failure analyses, operating time/cycle data and part/component replacements from component acceptance testing through system test.

These reports provide a continuous quality performance index that identifies the acceptable, marginal, and unacceptable suppliers. The data provided is used for source selection, recognition of exceptionally high quality suppliers, and in case of marginal or unacceptable suppliers, the data is selectively used for in-depth analysis by Product Assurance, Reliability, Research and Engineering, Manufacturing, and Procurement to determine the courses of action to be taken to eliminate the conditions encountered.

2.5.9 POST AWARD SURVEY OF SUPPLIER OPERATIONS

In addition to the normal vendor surveillance, a post-award survey may be conducted. During this survey a quality engineer visits the supplier's plant while the hardware is being produced, takes a first-hand look at the step-by-step in-process activity, pointing out areas of deficiency and suggesting corrective action (where required).

2.5.10 COORDINATION OF CONTRACTOR-SUPPLIER INSPECTIONS AND TESTS

For procurements involving major components, or subcontracts where incompatibility of test equipment and procedure could present difficulties, the supplier is required to submit a test plan in accordance with the Statement of Work and "Quality Plan for Earth Resources Technology Satellite A&B Subcontracts", Document Number 69SD4379, including equipment setup, to be reviewed (subject to disapproval) by General Electric.

2.5.11 NONCONFORMANCE INFORMATION FEEDBACK

GE-SS Quality Assurance Procedures 8.1 "Nonconforming Material Control and Disposition of" and 8.2 "Material Review Activity with Supplier" have been established and implemented for processing and disposition of supplier discrepant material, assurance of positive supplier corrective action, and, if required, providing of supplier Failure Analysis Reports on returned material prior to submission and acceptance of additional like items. The procedures provide for a closed loop system that verify the acceptability of corrective action before the article continues processing.

Vendor Quality Assurance Problem Reports are issued by the cognizant Supplier Product Assurance Engineer when information from responsible sources reveal nonconforming material or a need exists for supplier action to preclude recurrence of reported discrepancies. Vendor Quality Assurance Problem Reports are generated from information received from many sources. For example:

1. If the purchased item has been subjected to failure analyses and supplier action is required, it is noted in the Failure Analysis Report
2. Test areas submit Nonconformance Reports which are screened to determine the need for supplier corrective action
3. Customer complaints are reviewed
4. In-plant rejections are another source for possible supplier action

The supplier is required to reply to the Vendor Quality Assurance Problem Report. When the supplier's statement is received, it is analyzed to determine whether the supplier's answer is satisfactory or unsatisfactory, to insure that proper corrective action has been taken to prevent future defects.

2.6 FABRICATION CONTROLS

2.6.1 FABRICATION OPERATION

The plan for the control of articles fabricated by General Electric for the Earth Resources Technology Satellite Program is based on proven existing manufacturing and quality systems now being used for the control of space equipment. In addition, the knowledge derived during the design and development cycles at GE will be utilized in the establishment of specific manufacturing and quality planning. The present system which will be utilized provides the manufacturing and quality procedures and processes required for long life flight hardware. Flexibility is designed into the quality system in order to rapidly incorporate changes as requirements change or trends indicate modification to the quality program.

2.6.2 ARTICLE AND MATERIAL CONTROLS

Key points designated "Tollgates" will be established for acceptance of articles throughout the manufacturing flow. Acceptance of an article, in general, will constitute the completion of in-process inspection and/or test with appropriate disposition of nonconformances accomplished, and the successful completion of a performance test.

Inspection and test planning and/or instructions provide the direction for measuring the quality level for designated points in the manufacturing flow.

Product Assurance and Manufacturing Operations shall prepare and maintain a fabrication, inspection and test Flow Charts indicating the location of inspection and control points and test operations for the entire phase of fabrication, processing, assembly, test and shipping.

TABLE 2.5-4. EARTH RESOURCES TECHNOLOGY SATELLITE MAJOR SUBCONTRACTORS EVALUATION

Earth Resources Technology Satellite Major Subcontractors	General Electric Approved Supplies	Previous Program Usage	Current Program Usage	Significant Problems	Subsystem Provided
RCA	*	All Nimbus vehicles	Nimbus D	None	Power Subsystem Clock
Calfor Computer	Yes	All Nimbus vehicles	Nimbus D	None	Interface Switch Module
Radiation Inc.	*	All Nimbus vehicles	Nimbus D	None	Versatile Information Processor
Sperry-Rand	*	None	Nimbus D	None	Rate Measuring Package
Fairchild-Hiller	*	None	Nimbus D	None	Structure and Thermal Subsystem
Ithaco	Yes	None	Nimbus D	None	Roll Reaction Wheel Scanner, Control Logic Box, Signal Processor, Magnetic Moments
TRW	*	None	Nimbus D	Sterrer Regulator	Solar Array Drive, Pneumatics
Bendix	Yes	OAO, Nimbus	Nimbus D	None	Pitch, Yaw Flywheels
Nortronics	*	None	Nimbus D	None	Yaw Rate Gyro
Rocket Research		None	None	--	Orbit Adjust

*Equipment provided by these major subcontractors was previously provided to General Electric as GFE by NASA GSFC. General Electric will evaluate these suppliers prior to procurement.

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2.6.2 ARTICLE AND MATERIAL CONTROLS

Key points designated "Tollgates" will be established for acceptance of articles throughout the manufacturing flow. Acceptance of an article, in general, will constitute the completion of in-process inspection and/or test with appropriate disposition of nonconformances accomplished, and the successful completion of a performance test.

Inspection and test planning and/or instructions provide the direction for measuring the quality level for designated points in the manufacturing flow.

Product Assurance and Manufacturing Operations shall prepare and maintain a fabrication, inspection and test Flow Charts indicating the location of inspection and control points and test operations for the entire phase of fabrication, processing, assembly, test and shipping.

TABLE 2.5-4. EARTH RESOURCES TECHNOLOGY SATELLITE MAJOR SUBCONTRACTORS EVALUATION

Earth Resources Technology Satellite Major Subcontractors	General Electric Approved Supplies	Previous Program Usage	Current Program Usage	Significant Problems	Subsystem Provided
RCA	*	All Nimbus vehicles	Nimbus D	None	Power Subsystem Clock
Calfor Computer	Yes	All Nimbus vehicles	Nimbus D	None	Interface Switch Module
Radiation Inc.	*	All Nimbus vehicles	Nimbus D	None	Versatile Information Processor
Sperry-Rand	*	None	Nimbus D	None	Rate Measuring Package
Fairchild-Hiller	*	None	Nimbus D	None	Structure and Thermal Subsystem
Ithaco	Yes	None	Nimbus D	None	Roll Reaction Wheel Scanner, Control Logic Box, Signal Processor, Magnetic Moments
TRW	*	None	Nimbus D	Sterrer Regulator	Solar Array Drive, Pneumatics
Bendix	Yes	OAO, Nimbus	Nimbus D	None	Pitch, Yaw Flywheels
Nortronics	*	None	Nimbus D	None	Yaw Rate Gyro
Rocket Research		None	None	--	Orbit Adjust

*Equipment provided by these major subcontractors was previously provided to General Electric as GFE by NASA GSFC. General Electric will evaluate these suppliers prior to procurement.

Production tools and layout boards used for the fabrication of the Earth Resources Technology Satellite electrical components and harness assemblies for the flight vehicles will be controlled to assure that they are in compliance with the latest applicable engineering definition. The configuration of each layout board will be so indicated on the board and verified by Inspection per inspection planning requirements.

Material Control - Material for use on the Earth Resources Technology Satellite hardware will be identified and controlled per Quality Assurance Procedure 6.9 "Raw Material from Storeroom to Production, Control of", and Quality Assurance Procedure 6.10 "Control of Shelf Life of Organic Materials".

2.6.3 CLEANLINESS CONTROL

Electrical Component and Harness Assemblies -- Electrical harness assemblies will be fabricated in the GE-SS Harness Shop. This shop exercises cleanliness controls in compliance with the requirements of Quality Assurance Procedure 6.12, "Cleanliness, Control of".

BTE and AGE Fabrication - No specific cleanliness controls are required for the fabrication of BTE.

Earth Resources Technology Satellite Assembly and Test - Inspection personnel have the responsibility of monitoring the following areas for compliance with the cleanliness requirements:

Receiving Inspection

1. White nylon gloves must be worn when handling/inspecting all Earth Resources Technology Satellite components, including GFE Components. Clean gloves will be issued on a daily basis.
2. Upon completion of receiving inspection, each component will be externally vacuum cleaned, placed in plastic bags, and put in padded handling containers.

Component Test Area

1. Earth Resources Technology Satellite components received by the area and on hold awaiting test will be stored in padded closed containers.
2. Prior to start of test, each component will be examined for evidence of dust, scratches or finger prints.
3. When so specified by the applicable test Standing Instruction or Test Requirement, white nylon gloves will be worn in handling Earth Resources Technology Satellite components.

4. At all times during test of Earth Resources Technology Satellite components, good housekeeping practices shall be followed to insure that the components will not be subjected to unclean conditions. Dust caps will be placed on all connectors not connected and protective covers placed over the component when delays in the test cycle occur.

5. On completion of the test cycle, each component must be externally vacuum cleaned and placed in the container in which it was received.

6. When the Earth Resources Technology Satellite Components are in the Component Test Area for vibration, the cleanliness requirements to be implemented will be defined in the Test Instructions.

In-Process Inspection (Mechanical)

1. All components and structural assemblies delivered to the In-process Inspection Area for inspection and/or alignment will be properly wrapped or placed in padded containers.

2. White nylon gloves must be worn by inspectors when handling or inspecting components and structural assemblies.

3. Added special cleanliness requirements will be specified by the applicable inspection planning or procedure.

4. While the spacecraft or subsystem is in the alignment area, it shall be covered with a plastic cover when work is not in process.

5. Prior to releasing a component or structural assembly from the In-process Inspection Area, it must be externally vacuum cleaned then enclosed in plastic bags and/or placed in the padded containers in which the components were received.

6. Discrepancies found relative to cleanliness and general condition will be documented on the appropriate discrepancy report and disposition obtained prior to proceeding with further inspection effort.

Final Assembly and Systems Test

1. Final Assembly Inspection personnel will be responsible for monitoring the Test and Assembly Areas in which they are assigned for compliance to the cleanliness requirements established for the particular area. In general, the requirements are the same as Item B (Component Test).

2. Violations of cleanliness requirements will be reported to the responsible test conductor or assembly foreman and documented in the area log book.

3. Special cleanliness requirements will be defined by the applicable inspection planning. When hardware does not meet the program cleanliness requirements, a GSFC Malfunction Report will be generated defining the discrepancy.

2.6.4 PROCESS CONTROLS

Process specifications and certifications for metallurgical, chemical, and physical processes will be available for critical operations during the Earth Resources Technology Satellite hardware fabrication cycle. These specifications are related to production through Manufacturing Standing Instructions (MSI's) and present detailed step-by-step procedures for the operators to follow. The MSI's are prepared with the cognizance and approval of a Product Assurance Process Control Engineer and include inspection tollgates; for example, the inspection of the proportionate weights of materials during the preparation of encapsulant material. The MSI's are referenced in the Manufacturing Planning.

The manufacturing planning specifies the processes to be performed by certified operators. The Product Assurance planning for the article specifies only certified inspection of such processes.

The procedures applying to certification are:

QAP	7.3	Hand Soldering, Control of
QAP	13.1	Operator/Inspector Certification Program
QAP	13.2	Test Conductors, Certification of

All soldering will be performed in accordance with NHB 5300.4 (3.A) as defined by QAP 7.3, and the Earth Resources Technology Satellite Soldering Plan.

2.6.5 WORKMANSHIP STANDARDS

General Electric Manufacturing shall provide, where necessary, wire dress photographs of electric components and assemblies, and 3 dimensional harness boards for fabrication of harness assemblies. These work aids will be verified by Product Assurance prior to usage in production of flight hardware.

2.7 INSPECTIONS AND TESTS

2.7.1 GENERAL

General Electric planning and conduct of the inspection and test program shall insure that the contractual, drawing, and specification requirements are met.

2.7.2 INSPECTION AND TEST PLANNING

Inspection planning is the medium by which Product Assurance translates the engineering requirements of the drawings and specifications into a method to be used by the inspector in measuring how well a manufactured product conforms to the design and quality requirements.

The following factors shall be considered when planning is prepared:

1. Complexity of the Item - If the item is of a complex nature having many critical attributes, the planning shall be of a more detailed nature assuring that all critical attributes are fully covered.
2. Degree of Inspection Required - Subassemblies or assemblies which, due to the nature of the assembly cycle, contain areas which may be closed-up by sequential operations and which will preclude their inspection later in the cycle, will be planned calling for in-process inspections.
3. Complexity of the Measurement Equipment - Where complex measuring equipment should be used to obtain a measurement, planning will reflect the equipment to be used.
4. Degree of Competence of the Personnel Performing the Measurement Function - When a specialist, specifically trained for a particular type of inspection is required (for example: welding inspection, alodining, ultrasonics), a statement of that fact shall be reflected in the planning.
5. Feedback Information Required - If feedback information is required, the planning shall present a plan for gathering the data and forwarding of the data to the responsible person for analysis and follow-up.
6. Specifications Requiring Interpretation - Reference to Contractual Documents, NASA or Military Specifications and Department Instructions will not be made in the Product Assurance Planning. These documents will be interpreted by Quality Engineering and the interpretation shall be reflected in the planning.
7. Special Processes - Where a special process is included in the manufacturing cycle and detailed inspection instructions have been incorporated in issued Process Specifications or Manufacturing Standing Instructions, reference to these instructions by document and paragraph number may be made in the planning when applicability has been determined by the product assurance planner.

8. Safety Considerations - Items containing explosives or any other hazardous properties will be planned and the planning will specify that a safety hazard exists. Details will specify special handling techniques to be used by the inspector.

Detailed written inspection planning will be prepared by Product Assurance Quality Engineering for the ERTS component and harness assemblies and the assembly of subsystems for the flight A&B units. Inspection planning will identify the item to be inspected by drawing number, nomenclature, use number and serial number. It will specify types of measuring equipment to be used, including range and accuracy. It will also define methods of inspection, environmental conditions required, special precautions necessary and criteria for passing or failing items and acceptable tolerances. Inspection planning used for the inspection of ERTS equipment will comply with the requirements of Quality Assurance Procedure 6.1, "Fabricated Prime Equipment, Planning and Inspection of".

Detailed test procedures will be prepared for the acceptance testing of subsystems test equipment and for performing environmental and performance testing of the Flight Spacecraft. Tests to be performed on ERTS A&B are defined in the ERTS Integration and Test Plan.

2.7.3 TEST SPECIFICATIONS

Component test requirements will be generated as part of the component specifications from which detailed test procedures will be prepared by Product Assurance for in-house testing, and by suppliers, subject to General Electric and NASA-GSFC approval, for testing performed out of house.

The test procedures prepared shall contain block diagrams showing the complete set-up, a list of equipment and facilities to be used with accuracies specified and the step-by-step test instructions, including the limits for acceptance at each test condition.

2.7.4 INSPECTION AND TEST PROCEDURES

Inspection Procedures (Product Assurance Inspection Planning) and Test Procedures (Component Standing Instructions) shall be prepared in accordance with Quality Assurance Procedures 6.1, "Fabricated Prime Equipment, Planning and Inspection of", and 6.3, "Component Standing Instructions". The procedures will define in detail each inspection and test operation, inspection and test criteria and include values for acceptance and rejection. These documents will be available at all times during the performance of each inspection and test operation.

2.7.5 END ITEM INSPECTION AND TEST SPECIFICATIONS AND PROCEDURES

End item inspection will be performed in accordance with inspection planning prepared by the Performance Assurance Subsection in accordance with Quality Assurance Procedure 6.1, "Product Assurance Inspection Planning".

End item inspection planning will be prepared to assure that successful inspection will validate the end item to the top assembly or system drawing.

End item test will be performed in accordance with End Item Test Procedures. These detailed procedures will be prepared in accordance with the integrated test requirements for the ERTS spacecraft, and successful results will verify compliance to the end item specification.

Performance Assurance will review end item test procedures and monitor complete test operations in accordance with the requirements specified in the Test Monitor and Control Plan.

2.7.6 INSPECTION AND TEST PERFORMANCE

2.7.6.1 Inspection

Results of inspections on ERTS hardware will be documented on the applicable inspection planning. Figure 2.7-1 shows the component assembly flow.

Nonconformance to inspection requirements will be documented on a GSFC Malfunction Report. Table 2.7-1 shows the components to be fabricated by General Electric.

Each manufacturing operation or inspection is traceable to the individual responsible for its accomplishment through the use of operator and inspector stamps.

During hardware inspection defects found are analyzed by Process Control Engineering and Quality Engineering for the purpose of determining and initiating corrective actions or defect prevention. Weekly defect reports are issued by Product Assurance Process Control Engineering (SPOTS Report) with unacceptable or out-of-control conditions indicated. Appropriate management action will be taken to correct out-of-control conditions.

2.7.6.1.1 GFE Component Bench Test

Inspection should:

1. Assure that required documentation accompanies GFE components when delivered to the ERTS bonded stock. This documentation should include: travel tags, GFE supplier test data/log book, and malfunction reports, if applicable.
2. Generate and maintain a workbook for each component which will reflect all activities performed on the component prior to installation on the vehicle.
3. Verify that each test set-up is per the applicable test procedure.
4. Monitor testing on a periodic basis depending on the nature of the test to ensure that test data is being recorded per requirements of the test procedure. The amount of inspection surveillance testing will be determined by the inspection supervisor.

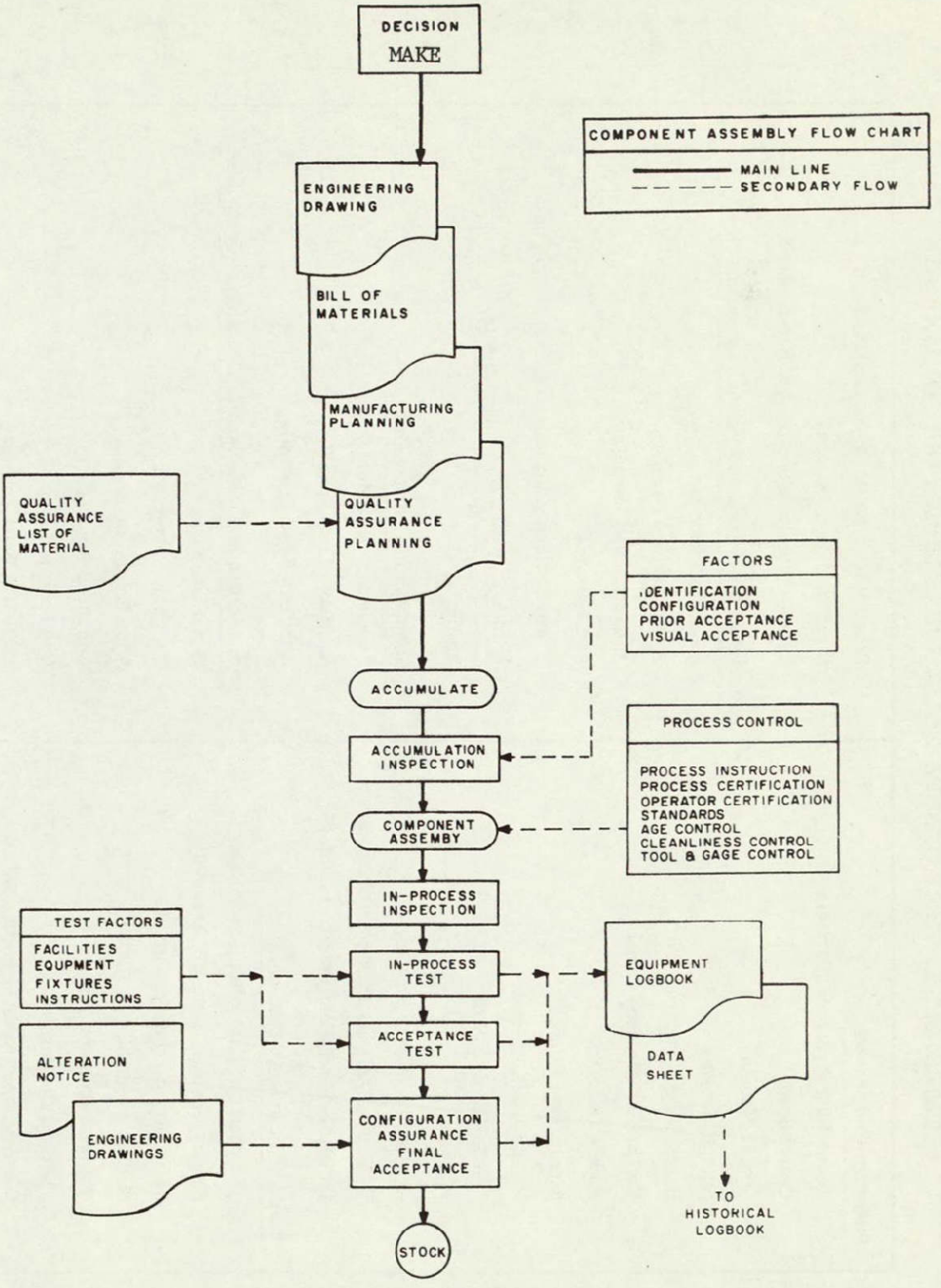

Figure 2.7.1. Component Assembly Flow Chart

TABLE 2.7-1. ERTS GENERAL ELECTRIC FABRICATED COMPONENTS

Structure Components	Sensory Ring Lower Insulation Blankets
Torus Ring Structure (Partial)	Strut Insulation Blankets
Cross Beam	Paddle Transition Section Insulation Blankets
Sensor Mounts	**Electrical Integration Subsystem Components**
Antenna Mounts	Spacecraft Harness
Harness Support Structure	Flight Adapter Harness
ERTS/ACS Interface Panel	Antenna Model Harness
Paddle Dampers	ACS Harness
Separation Switches	Power Switching Module
Paddle Latch Hardware	**Attitude Control Subsystem Components**
Paddle Unfold Switch	Insulation
Load Cells	**Power Subsystem Components**
Adapter Secondary Structure	Separation and Unfold Timer
Wide Band Antenna Pickup and Reradiator	Auxiliary Load Panel
Unified S-Band Pickup and Reradiator	Auxiliary Load Controller
Thermal Subsystem Components	**Communication and Data Handling Subsystem Components**
Temperature Controller Assembly	Conditioner Box
Shutter Position Indicator Assembly	Command Integrator
Telemetry Conversion Circuits	Wide Band Antenna
Shutter Assembly	Command Antenna
Thermal Radiator Plate	Quadraloop Antenna
Thermal Coatings	Unified S-Band Antenna
Sensory Ring Upper Insulation Blankets	

5. Maintain a mate-demate log for each component.
6. Assure that component operating time is recorded on the required form.
7. Assure that all anomalies occurring in GFE components are documented on GSFC Malfunction Reports.
8. Verify that all retesting and/or trouble shooting is accomplished to applicable documented instructions.
9. Assure that ERTS program cleanliness requirements are implemented during all testing.
10. Assure that all components are handled and stored in an acceptable manner.

2.7.6.2 Component Test

2.7.6.2.1 Development Tests

When development tests are performed, as defined in the Integrated Test Plan, tests will be conducted under the direction of Research and Engineering. The objective is to assess the adequacy of a packaged design during operation and under selected environmental exposure.

2.7.6.2.2 Bench Acceptance Tests

Appropriate functional and environmental acceptance tests will be performed on components shown in Table 2.7-2 to verify specification compliance. The test articles will be identical to the qualification test specimens with respect to physical characteristics and in methods and controls used in their fabrication except for authorized change incorporation. Acceptance tests will provide the means of ascertaining the hardware meets workmanship standards and specified environmental and performance criteria. Acceptance and Qualification Test Flows are shown in Figure 2.7-2.

Test articles will be identified by a part number and a serial number. As in qualification testing, no repairs, adjustments, or maintenance will be permitted unless adjustments are called for in the standing instructions. All operating time, time to failure, and time during which the item is subjected to environmental or other stresses will be measured and entered on the data sheet. Nonconformances will be reported in accordance with applicable GE-SS Quality Assurance procedures and will be transcribed on GSFC Malfunction Report 4-2.

Performance criteria will be established by the applicable design and environmental specifications. All test data will be authenticated by the responsible test engineer, documented on performance data sheets, and verified by Product Assurance.

TABLE 2.7-2. ERTS COMPONENTS TO BE ACCEPTANCE TESTED BY GENERAL ELECTRIC

Structure Components
Paddle Dampers
Separation on Switches
Paddle Unfold Switch
Load Cells
Separation Springs
Thermal Subsystem Components
Temperature Controller Assembly
Shutter Position Indicator Assembly
Telemetry Conversion Circuits
Compensating Loads
Electrical Integration Subsystem Components
Spacecraft Harness
Flight Adapter Harness
Antenna Model Harness
ACS Harness
Power Switching Module
Power Subsystem Components
Separation and Unfold Timer
Auxiliary Load Panel
Auxiliary Load Controller
Communication and Data Handling Subsystem Components
Conditioner Box
Command Integrator
Wide Band Antenna
Command Antenna
Quadraloop Antenna
Unified S-Band Antenna

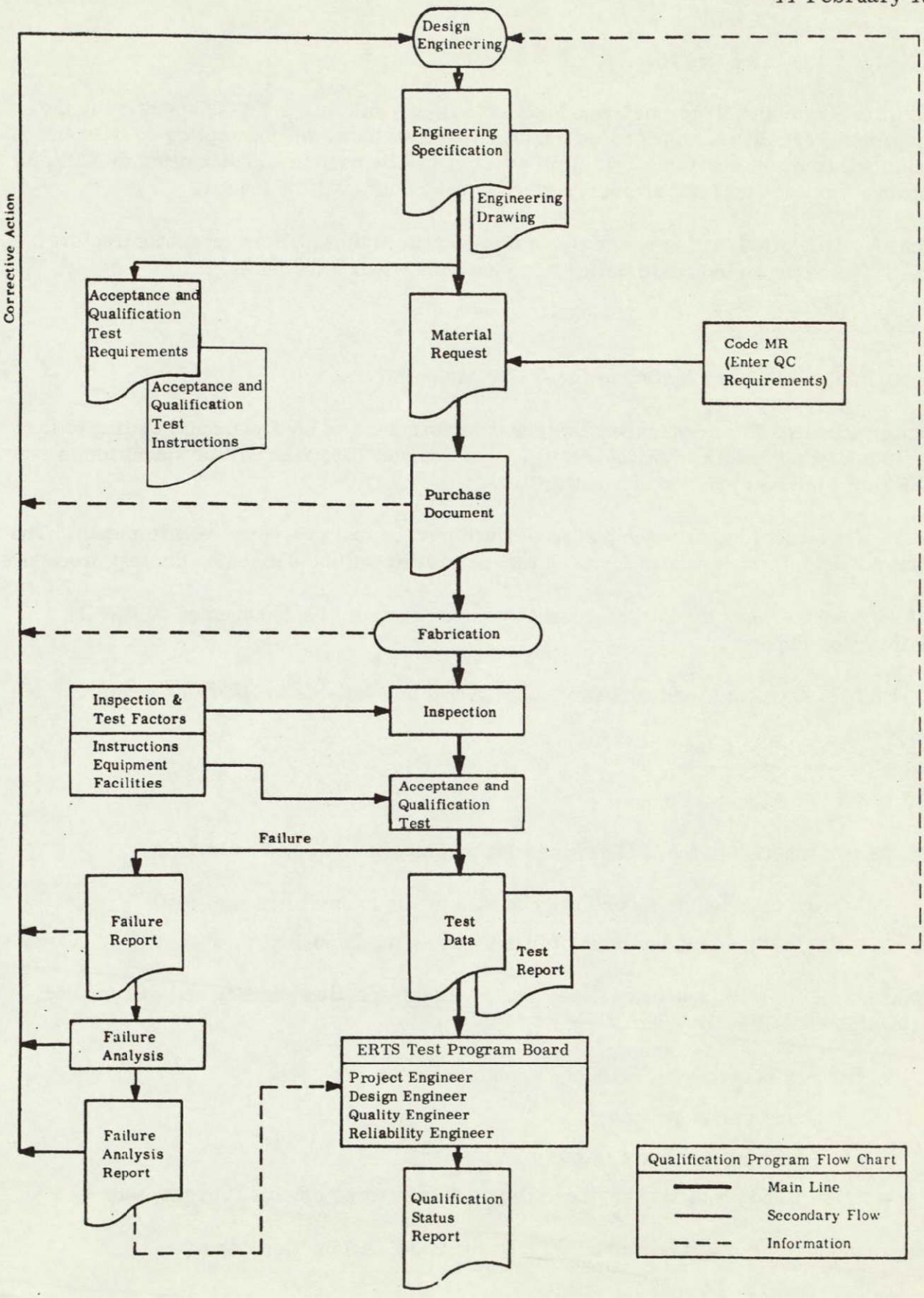

Figure 2.7-2. Acceptance and Qualification Flow Chart

2.7.6.2.3 Qualification Tests

Qualification tests will be performed on items listed on Table 2.7-3 as specified in the Integrated Test Plan. An approved qualification test status will be kept up-to-date and submitted to NASA quarterly. Test procedures will be written and submitted to NASA for approval for each test and a report covering test results will be issued.

Where qualification testing of components is conducted by suppliers or subcontractors, GE-SS will approve the qualification test plans and witness the testing.

2.7.6.3 End Item Test

Inspection will monitor testing of the ERTS Spacecraft.

Test procedures for acceptance testing and performance of environmental testing of the ERTS subsystems defined by the ERTS Integration and Test Plan will be submitted to NASA for approval prior to conducting tests.

Data will be recorded for each test performed per the test procedure requirements. The nominal and tolerance values for each test parameter will be defined on the test procedure.

All nonconformances to test procedures requirements will be documented on GSFC Malfunction Reports.

All ERTS subsystems, and systems test data will be available to NASA for review.

2.7.6.4 Final Inspection

2.7.6.4.1 Final Inspection

The final inspection of the ERTS spacecraft will be accomplished as follows:

1. After completion of performance tests prior to environmental tests
2. Flight - prior to packaging for delivery to the Launch Site.

Final inspection will be accomplished per detailed inspection planning and will include, as a minimum, the following:

1. Check of connector mate/demate status
2. Damage to components
3. Maintaining hardware torque requirements
4. Required protective devices such as dust covers, shields, covers, etc.

Discrepancies found will be documented on the GSFC Malfunction Report.

TABLE 2.7-3. ERTS COMPONENTS REQUIRING QUALIFICATION TEST BY GENERAL ELECTRIC

Electrical Integration Subsystem Components
Power Switching Module
Communication and Data Handling Subsystem Components
Conditioner Box
Command Integrator
Wide Band Antenna

All changes of components or modifications to ERTS subsystems after final test and inspection will require retest and re-inspection will be determined by the ERTS Program Manager and concurred to by NASA.

2.7.7 INSPECTION AND TEST RECORDS AND DATA

Inspection and test records and data shall be accumulated and stored in accordance with Section 2.4.6 of this plan.

2.7.8 CONTRACTOR QUALITY ASSURANCE ACTIONS

Product Assurance personnel shall monitor and assure test conformance in accordance with Test Monitor and Control Plan (Appendix 2.C).

2.8 NONCONFORMING ARTICLE AND MATERIAL CONTROL

2.8.1 NONCONFORMING ARTICLE AND MATERIAL CONTROL

The nonconforming material system as documented herein will provide for the identification, control, review, disposition and corrective action of material that does not conform to drawings and specifications (Figure 2.8-1). The system is responsive to immediate investigation of the nonconformances to ascertain the cause and responsibility. After the cause for the nonconformance is established, disposition to correct the immediate problem will be provided and then corrective action by those responsible will be taken to prevent recurrence of the nonconformance. Nonconformances will be reported on nonconformance report forms which will be coded to provide mechanized capabilities for issuance of summary reports.

Material review authority may be delegated to major subcontractors if, through General Electric audit, the subcontractor has in place a system for identification, documentation, segregation, control and disposition of nonforming articles and materials which complies with USAF Bulletin NR 515 (Control of Nonconforming Supplies), and such delegation has been approved through NASA-GSFC. In no case may second tier delegation be made by the subcontractor to his suppliers.

In those cases where the material review function has not been delegated, the limits of the suppliers and subcontractors material review authority shall be scrap for obvious scrap, rework for missing operations or return to vendor. All other dispositions (i.e. rework, not to drawing, use-as-is) shall require documentation and be submitted to General Electric for review and final dispositioning. GE-SS will utilize two systems for controlling and dispositioning nonconforming material on the ERTS Program.

The GE-SS system for control of nonconforming material fabricated in-house including components, harnesses and BTE prior to final acceptance and/or delivery to ERTS system test, will be per Section 8.0 of the Quality Assurance Procedures Manual except as modified herein.

All nonconformances in GFE and GE-SS fabricated equipment accepted for subsystems will be controlled and dispositioned utilizing GSFC malfunction reports.

2.8.2 NONCONFORMANCE DOCUMENTATION

GE Space Systems fabricated items prior to acceptance and/or systems tests. – The procedure for nonconforming material control shall be in accordance with the following:

1. Quality Assurance Procedure 8.1 -- "Nonconformance Reporting"
2. Quality Assurance Procedure 8.3 -- "Scrap Parts, Control of"
3. Quality Assurance Procedure 8.4 -- "Material Review Board Operation"

The following exception is taken to Quality Assurance Procedure 8.4, Paragraph 7.0 which will be implemented as follows:

1. Nonconformances that are classified as deviations will require a waiver from NASA and will be identified as such.
2. The MRB Board Chairman shall notify the ERTS Product Assurance Project Engineer of all such nonconformances.
3. The ERTS Product Assurance Project Engineer will be responsible for notifying the NASA Contracting Officer of such nonconformances. The NASA Contracting Officer will sign all Class I Nonconformance Reports.

Procedure for controlling and dispositioning GFE equipment in receiving inspection:

1. All discrepancies found on this type equipment will be documented on a GSFC Malfunction Report Form 4-2 dated 9-67 by Receiving Inspection.
2. When a GSFC Malfunction Report is generated, the ERTS Product Assurance Project Engineer will be notified of the malfunction report. He then will obtain the GE-SS recommended disposition from the responsible GE-SS Engineer who will also notify NASA of the discrepancy. The GSFC Malfunction Report will then be presented to the NASA Contracting Officer for approval within 48 hours.

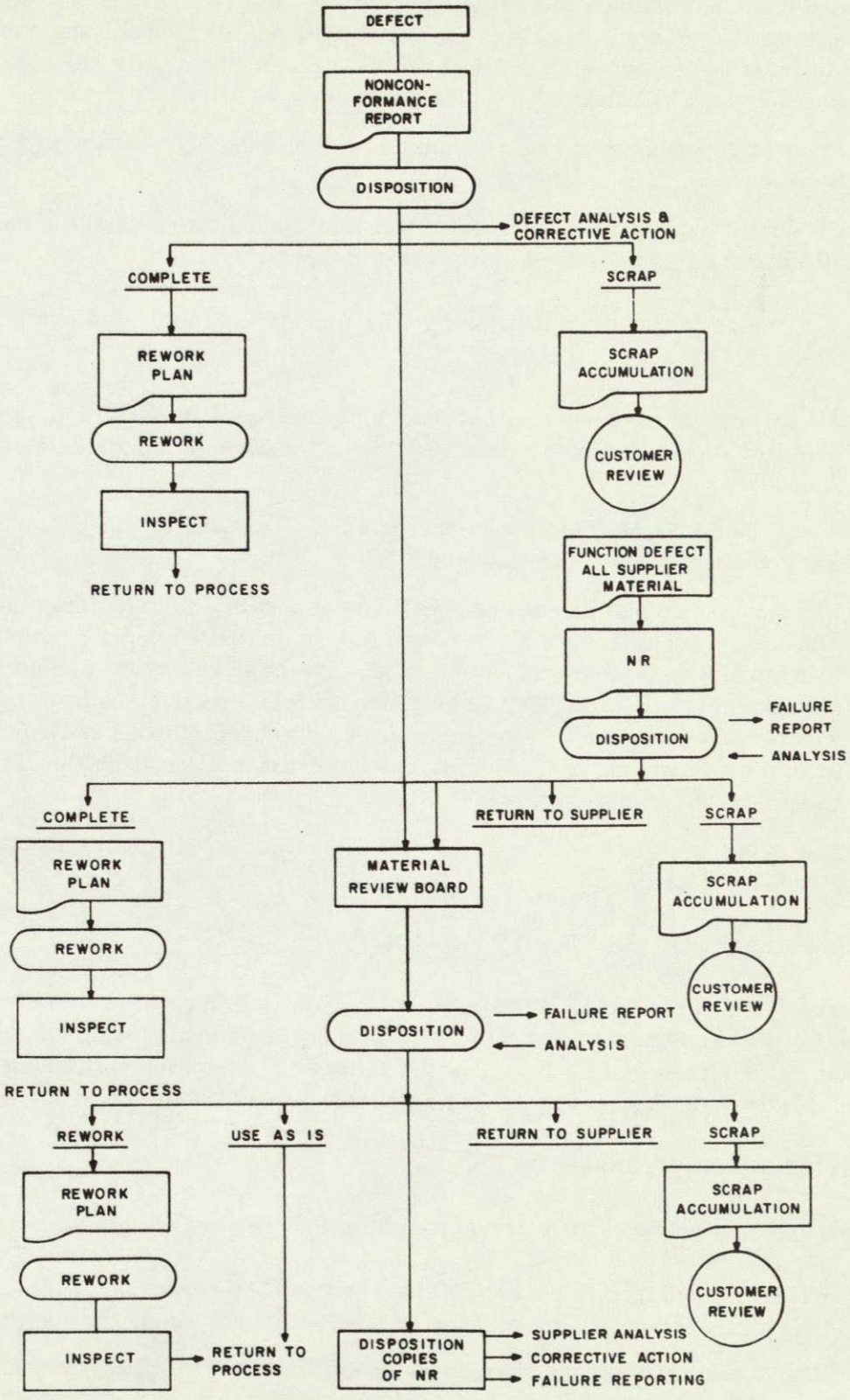

Figure 2.8-1. Nonconforming Material Flow Chart

3. After having obtained the NASA Contracting Officer's disposition on the GSFC Malfunction Report, the required action will be initiated and the complete GSFC Malfunction Report will be delivered to Product Assurance Reliability Assurance Engineering Operation.

4. Product Assurance will be responsible for making distribution of Malfunction Report copies.

5. Product Assurance will provide NASA Quality Assurance, with a monthly status of all outstanding and closed Malfunction Reports.

Procedure for controlling and dispositioning GFE and GE-SS fabricated equipment accepted for use in Systems Tests:

1. All discrepancies found on this type equipment will be documented on a GSFC Malfunction Report Form 4-2 dated 9-67 by either Inspection or ERTS Systems Test Support.

2. When the GSFC Malfunction Report has been written, it will be sent to the ERTS Performance Assurance Manager.

3. Product Assurance Engineering will be responsible for obtaining the recommended disposition from the GE-SS design engineer on test anomalies which occur during bench acceptance test or systems test. On those reports which pertain to hardware discrepancies (GFE, BTE, and GE hardware), Product Assurance Engineering will be responsible for obtaining the recommended disposition from the GE-SS design engineer and for obtaining customer disposition from the NASA T.O. or his delegated representative.

4. Distribution of dispositioned GSFC Malfunction Reports will be performed by Product Assurance.

2.8.3 REMEDIAL AND PREVENTIVE ACTION

Quality Assurance Procedure 12.4 "Corrective Action", defines the method and establishes the responsibilities for corrective action to be taken for nonconformances, including deficiencies, anomalies, malfunctions and/or failures, associated with the design, procurement, manufacture, testing, inspection and delivery of hardware.

2.8.4 INITIAL REVIEW DISPOSITIONS

The following general procedure will be utilized to process non-conforming material reports:

1. A Nonconformance Report (NR) shall be used for reporting departures from drawings and specifications encountered within the scope of this plan.

2. When a departure from drawing or specification is detected during inspection or test, the material shall be withheld or removed from production when practicable, and an NR initiated by the Inspector/Tester.

3. The nonconforming condition shall be reviewed by the Quality Assurance Inspection/ Test Supervisor and/or the cognizant Quality Control Engineer. The Quality Assurance Supervisor shall provide a preliminary disposition and validating signature on the report after verifying the completeness of data on the Nonconformance Report. Preliminary dispositions shall be limited to:

   a. Return to Vendor

   b. Scrap

   c. Rework to Drawing/Specification

   d. Use as is with an Alteration Notice

   e. Refer to MRB

4. When material is diverted from normal inspection channels and referred to the Material Review Board, the material shall be identified with a "D" Stamp, and, if size permits, the material shall be stored in a quarantine area. The product assurance nonconforming material control representative shall send notification to MRB members when the material is ready for review. Following a decision of the Material Review Board, the completed case history shall be filed, and copies of the Nonconformance Report shall be issued in accordance with established distribution lists, including a copy to Configuration Control for incorporation into Component Log Book.

5. If the decision of the Material Review Board is "Use As Is", an "A" Stamp shall be interlocked with the "D" Stamp. The material shall then be released to Product Control and processed as normal material. A copy of the Nonconformance Report shall accompnay the material. If the "Use As Is" decision is a result of an Alteration Notice, the AN number shall be referenced in the Disposition column. If the "Use As Is" decision restricts the usage of the material, the restrictions must be clearly stated in the disposition and an "E" Stamp, shall be interlocked with the "D" Stamp, e.g., Engineering Use Only, etc.

6. If the decision of the Material Review Board is "Rework, the material shall be forwarded to Production Control for accomplishment of the rework in accordance with manufacturing/inspection rework planning. Two (2) pink copies of the Nonconformance Report shall accompany the material. When the work is completed, the inspector confirming the accomplishment of it, shall stamp the material and paperwork. The inspector shall retain one (1) pink copy with the material and return the other stamped pink copy of the Nonconformance Report to the Material Review Board for attachment to the master as a permanent record. In those instances where the disposition states "rework and retest", the tester, confirming the acceptability of the retest, shall stamp the material and paperwork including the Nonconformance Report copy, as specified above.

7. If the decision of the Material Review Board is "Repair", the material shall be forwarded to Production Control for accomplishment of the necessary work. Two (2) pink copies of the Nonconformance Report shall accompany the material. When the work is completed, the inspector/tester confirming the repair/retest shall stamp the material and paperwork. The inspector/tester shall retain one (1) pink

copy with the material and return the other stamped pink copy of the Nonconformance Report to the Material Review Board for attachment to the master as a permanent record.

8. If the decision of the Material Review Board is "Return to Vendor" the Product Assurance MRB Representative shall:

   a. Contact the responsible Product Assurance Planner for Nonconformance Report coding.

   b. Document the Shipping Notice and new Purchase Order Number to close out the Nonconformance Report and forward material to Production Control.

9. If the decision of the Material Review Board is "Scrap", the material shall be disposed of in accordance with Quality Assurance Procedure 8.3 entitled, "Scrap, Control of".

2.8.5 MATERIAL REVIEW BOARD (MRB)

The GE Space Systems Organization MRB is a contractor-government board established for the purposes of reviewing and approving the disposition and corrective actions that do not conform to drawings and specifications.

The Material Review Board consists of:

1. An approved representative from Product Assurance
2. An approved representative from Research and Engineering
3. A government representative

The Material Review Board determines final disposition of hardware submitted.

The Product Assurance representative acts as coordinator of the Material Review Board. The Board has the responsibility to assure that material accepted for use as is, will not adversely affect safety, performance, interchangeability, weight, or specified reliability.

Consulting or advisory services may be requested of other personnel by any member of the Material Review Board. Advisory or consulting personnel shall have no participation in the disposition of material.

Acceptance of a nonconformance submitted to the Material Review Board requires a unanimous approval of all Board members.

2.8.5.1 Scope of MRB Authority

Nonconformances which must be submitted to MRB for acceptance are classified as follows:

1. Class I Nonconformance - Any nonconformance that could by itself or by its relation to other components, result in failure or malfunction, involve safety of personnel

using or maintaining the item, adversely affect performance durability, interchangeability, reliability, materially affect weight, or otherwise result in failure of the end product to perform its intended function.

2. Class II Nonconformance - Any departure from established standards of workmanship or other similar standards in a manner or to a degree which has no subsequent bearing on the effective use or operation of the item or related component and which does not involve any of the factors defining a deviation.

3. Repair (Rework - Not To Drawing) - Material that may be repaired in a manner that is not covered by existing criteria, but will function after such repair without the adverse effects described in Paragraph 8.3.1 may be considered as a variation and the rework not to drawing can be authorized by MRB. Copies of Alteration Notices associated with rework not to drawing dispositions shall be attached to the Nonconformance report.

MRB dispositions which must be unanimous shall be provided as follows:

1. Scrap
2. Use as is - for nonconformances which do not adversely affect safety, reliability, durability, performance, interchangeability, weight or contract objectives.
3. Request NASA Contracting Officer Approval. Nonconformances which do affect safety, reliability, durability, performance, interchangeability, weight or contract objectives and for nonconformances where an acceptable repair can be made.

The product assurance MRB representative shall:

1. Provide the quality disposition for the Material Review Board,
2. Determine the need for initiating corrective action as a result of Material Review Board activities.
3. Convene Material Review Board meetings and/or obtain decisions of other board members.
4. Notify the Product Assurance Project Engineer of the disposition requiring NASA GSFC Contracting Officer approval.
5. Indicate on the Nonconformance Report whether the material is to be re-submitted to the Board after repair. If not, the material may be processed through regular inspection channels.
6. Establish a file of all Material Review Board actions that require follow-up at a later date to assure that the appropriate corrective action has been taken.
7. Assure that the corrective action at all levels of the Material Review System is adequate and effective.
8. Maintain the Material Review Board file of case histories.

9. The Nonconforming Materials Control section of Quality Assurance Engineering shall maintain control of nonconforming material, establish MRB action files, maintain case histories and process nonconformance reports.

The MRB research and engineering representative shall have the responsibility for:

1. Rejecting a nonconformance or determining engineering usability and acceptability of the nonconformance "As Is".
2. Or after repair to approved repair procedures, verifying that the extent of the nonconformance accepted is within the scope of MRB authority.

The government representative shall have the responsibility for:

1. Final authority for the acceptance or rejection of the nonconformances.
2. Final disposition of all government furnished material for nonconformances found in receiving inspection.

2.8.6 WRITTEN REQUESTS FOR NASA CONTRACTING OFFICER APPROVAL

Dispositions requiring NASA-GSFC Contracting Officer approval shall be submitted through the General Electric Contracting Officer to NASA-GSFC for approval. Copies of the nonconformance approval request shall also be submitted to the NASA-GSFC technical officer for review and approval.

2.8.7 SUPPLIER MATERIAL REVIEW BOARD

Unless the material review function is specifically delegated by General Electric and NASA-GFSC to the subcontractor, the limits of subcontractor material review authority shall be scrap for obvious scrap, rework for missing operations, or return to vendor. All other dispositions (i.e. rework not-to-drawing, use-as-is) shall require documentation and submittal to GE for review and final dispositioning.

Requirements for subcontractor procurement of MRB delegation shall include full compliance with USAF Bulletin NR 515 Amdt 2, (Control of Nonconforming Supplies) and the following as established by pre-award audit:

1. Submittal to GE for review and approval resumes for Design Engineering and Quality Assurance primary and alternate Material Review Board Members.
2. Submittal to GE for review and approval Quality Assurance Operating Procedures defining specific means for:
   a. Identifying, segregating, and documenting discrepant materials
   b. Limits of Materials Review authority
   c. MRB Records-keeping activity in a manner enabling rapid determination of problem recurrency

d. Maintenance of an MRB corrective action system to preclude recurrence of discrepancies

e. Means for controlling standard repairs and initiating corrective action in the instance of recurrent usage. Note that standard repair usage by the supplier is optional, but all such standard repairs shall be subject to review and approval on a one-time basis by GE and NASA GSFC.

3. An in-plant evaluation of actual MRB practices and work flow by General Electric.

4. Correction of all deficiencies in subcontractor MRB documentation and actual practices.

5. General Electric shall be provided with copies of dispositioned MRB cases within three (3) days after dispositioning.

6. No second tier MRB delegations may be made by the subcontractor to his suppliers.

Items requring further dispositioning by NASA-GSFC shall be treated as defined in Section 2.8.5 and 2.8.6.

2.9 METROLOGY CONTROLS

2.9.1 GENERAL

The Quality Information Equipment Control Program will provide for the maintenance of basic inspection standards, gauges, and other measurement and special test equipment to ensure that articles conform to specification and drawing requirements. This program includes all tools and equipment to be used on the ERTS Program. It also provides for control of all changes to inspection and test equipment and ensures that the equipment is calibrated at regularly scheduled intervals against approved measurement standards traceable to the National Bureau of Standards (see Figure 2.9-1). Written procedures will be used in the manufacture, test, and control of all hardware and processes. These procedures will include special schedules for each type of equipment which are consistent with use, accuracy, and precision required for the equipment. In addition, they ensure immediate removal from service equipment that has not been maintained, or recalibrated in accordance with established schedules, or has been found to exceed allowable limits. Records will be maintained on the calibration status of all measurement equipment.

The Department instructions and Quality Assurance procedures for controlling and maintaining inspection, measuring, and test equipment are as follows:

DI	8.1	Instrument Control
DI	8.9	Test Equipment, Control of
QAP	9.1	Measuring Standards, Control of
QAP	9.2	Test Equipment Control
QAP	9.3	Personally Owned Mechanical Precision Measuring Equipment
QAP	9.4	Gage Wear Policy
QAP	9.5	Calibration of Dimensional/Optical Measuring Equipment
QAP	9.6	Calibrated Manufacturing Tools, Control of
QAP	9.7	Special Inspection Tooling, Control of

2.9.2 ACCEPTANCE

Test equipment operating instructions and checkout procedures will be written to assist the test technician in the operation of the test equipment, and to assist the test equipment technician in the checkout of special test equipment. Where applicable, a Test Equipment Calibration Procedure will be generated and used by the Calibration Laboratory personnel to

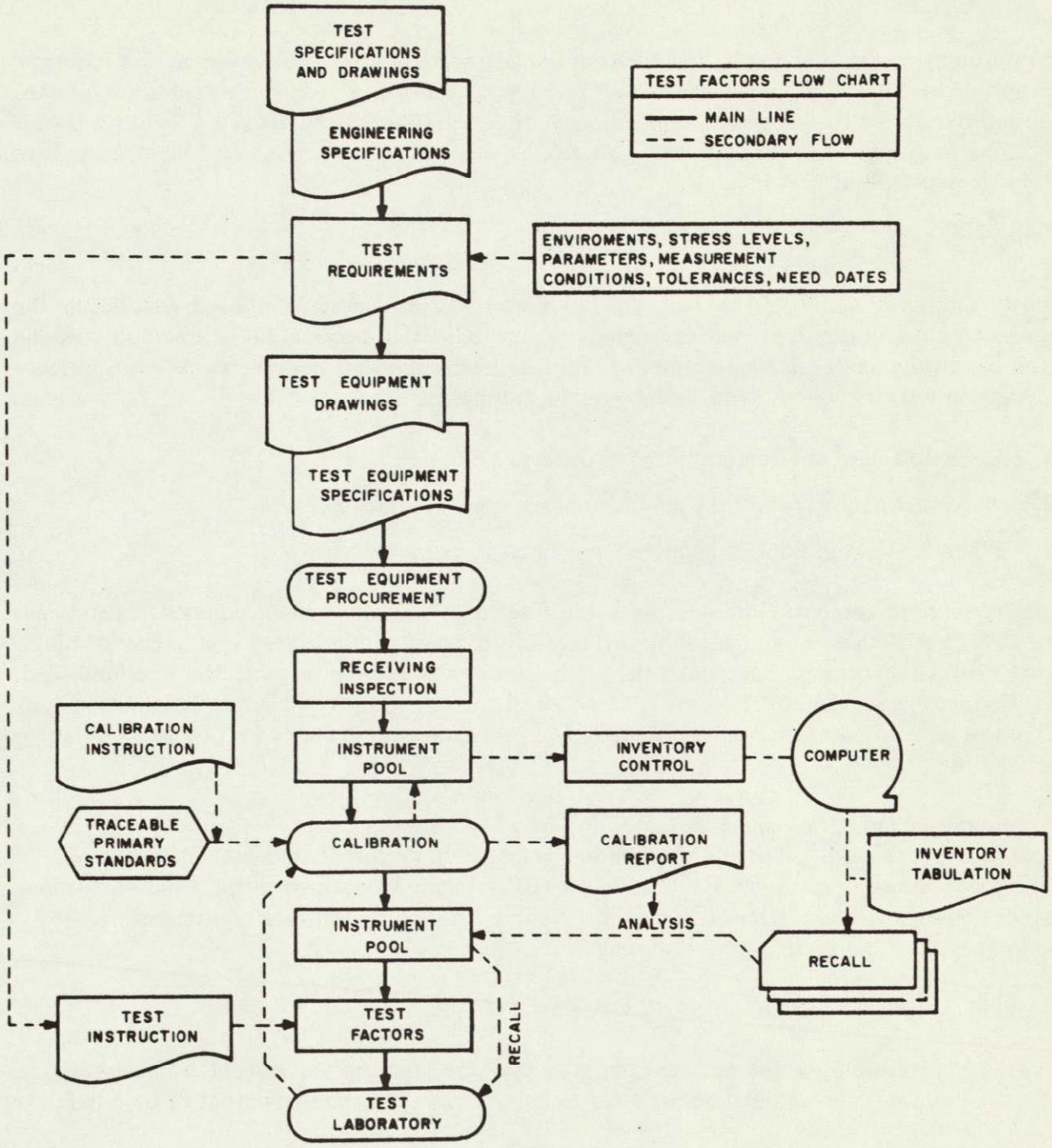

Figure 2.9-1. Test Factors Flow Chart

calibrate the Special Test Equipment. For internal control, each Test Equipment Design Task will have a project folder. This folder will contain such information as program plans, expenditures, schedules, material requests, laboratory instructions, and work authorization.

Prior to delivery to the test floor, the test equipment will receive an inspection and functional checkout. This checkout is accomplished by simulation of the item to be tested or by use of the actual hardware to be tested, depending on the nature of the hardware. Typical inspection functions are: hipot and leakage tests on cables, resonance searches on vibration fixtures, and safety inspections of test consoles.

2.9.3 EVALUATION

The Quality Engineer, Test and Operations Engineer, and/or Design Engineer will define the test requirements and the environments under which these tests are to be performed, depending on the hardware and test requirements. In describing the test requirements, the following information will be conveyed to the cognizant engineer:

1. Description of the tests and the article to be tested
2. Type and accuracy of test measurements and simulations
3. When test equipment is required and in what quantity.

Based on these requirements, the engineer will develop a test equipment concept. The preliminary design will then be subjected to a Design Review by a committee consisting of the equipment requestor, design engineer, the ultimate user of the equipment, the Product Assurance Engineer, and the ERTS Performance Assurance Manager. The participants at the design review will comment on the design concept and give concurrence before proceeding with the final design.

The test equipment being designed is controlled by assembly drawings, schematics, block diagrams, and parts lists. The test equipment is then either fabricated in-house or procured, or a combination of these. A change control system as defined in the Configuration Management Plan will ensure that the hardware being tested and the test equipment are always compatible from a configuration standpoint.

2.9.4 ARTICLE OR MATERIAL MEASUREMENT PROCESS

The General Electric inspection and test process provides for the use of test instruments where the instrument has a ten times greater accuracy than the measurement to be taken.

In cases where the state of the art does not permit this, authorization for exceptions will be requested from NASA-GSFA.

2.9.5 CALIBRATION MEASUREMENT PROCESS

Errors in calibration measurement processes will not exceed the measured parameter tolerance by more than 25 percent. Where this is not possible, due to state-of-the-art processes, exception authorization will be requested.

2.9.6 CALIBRATION CONTROLS

2.9.6.1 Instrumentation Control

The Measurement Equipment Engineering Laboratory has established and maintains a system of controls that will ensure GE - Space Systems of economical maintenance, maximum utilization, knowledge of location and status of all test equipment, both general purpose (Instrument Pool Equipment) and Special Test Equipment assigned to the test areas.

Instrument Pool items will have an identifying tag affixed to each instrument. This tag will remain attached to the instrument until it is removed from the Space Systems inventory. In addition, each instrument will have a historical record generated. This record will contain such information as: inventory control number, equipment name, manufacturer, model number, serial number, technical specifications and initial cost. Maintenance cost records will be accumulated so that determinations can be made on equipment whose continued use is economically questionable.

Special Test Equipment will be controlled in the same manner as pool equipment. The inventory control numbers will be affixed to test consoles so that each console may be treated as an entity. All the equipment contained in the console will be itemized on a top assembly drawing.

2.9.6.1.1 Calibration

Instrumentation used to measure or confirm the acceptability of prime hardware will be periodically maintained and calibrated to ensure its accuracy and dependability. To accomplish this effort, Space Systems Division has a calibration laboratory to provide calibration and certification of all instrumentation to the requirements called for in:

1. NHB 5300.4 (IB), "Quality Program Provisions for Aeronautical and Space Systems Contractors"
2. MIL-C-45662A, "Calibration System Requirements"
3. T.O. 33-1-14, "Calibration and Certification of Precision Measurement Equipment"
4. AFR 74-2, "Repair, Calibration, and Certification of Precision Measurement Equipment"

Calibration procedures are provided by Space Systems Product Assurance for use with all appropriate instrumentation. The instrumentation and test equipment will be calibrated at predetermined intervals by the Calibration Laboratory. The frequency of calibration will be specified by Product Assurance Equipment Engineering and will be such that the accuracy of the instrument is assured at all times. Historical records containing information on calibration, maintenance, repair, usage, etc. will be maintained. In addition, the Calibration Laboratory will have established procedures for obtaining periodic calibration at the National Bureau of Standards or other agencies whose standards are traceable to the NBS.

2.9.6.1.2 Identification

Upon completion of calibration, decal stickers will be attached to the equipment to designate its calibration cycle. Identifying stickers will be used to denote the following:

1. Equipment to be calibrated after each charge-out.
2. Equipment not to be used after date indicated on decal.
3. Equipment is a pool item and next calibration due date is based on when the equipment is removed from the instrument pool.

It is the responsibility of both the Calibration Laboratory personnel and the Product Assurance personnel performing acceptance tests to continually ensure that the equipment used is calibrated. Any equipment due for calibration will be immediately tagged and removed from service.

2.9.6.1.3 Recalibration Cycle

All equipment will be periodically scheduled to be inspected and recalibrated to determine that it has remained functional and has remained within its stated accuracy. The recall cycle is determined by statistical methods based on the age of the equipment, previous failure history, condition, and usage. This means that some equipment must be recalibrated frequently, while other equipment need be recalibrated only occasionally.

Calibration due dates for equipment that is controlled in the Instrument Pool will be based on its date of removal from the pool. This method reduces the frequency of calibration for instruments that may remain in the Instrument Pool for long periods of time.

2.9.6.2 Production and Inspection Tooling Control

The Space Systems Tool and Gage Laboratory will provide the inspection, calibration, and identification of all production and inspection tooling. This control includes GE- and Government- owned (as well as personally owned) equipment. Tooling will be stored in the tool and gage Crib in such a manner as to minimize damage, prevent rust or corrosion, and provide measures for meeting security regulations. The tooling will be made available only to authorized personnel.

2.9.6.2.1 Calibration

Inspection tools will be calibrated periodically. The calibration interval will be dependent upon the type of tooling, the number of times the tool is used, or defined calibration time intervals. Records of calibration data will be maintained on the individual record cards for each tool. All primary and secondary standards used to calibrate tools will have their calibrations traceable to the National Bureau of Standards and evidence of this traceability will be maintained in the Calibration Laboratory.

2.9.6.2.2 Personally Owned Equipment

Personally owned employee equipment must be submitted to the Tool and Gage Laboratory for recording, inspection, and calibration prior to its use. These tools will be processed similarly to company owned tools. In addition, the laboratory will submit copies of the calibration records to the owners so that they will be informed of the status of their equipment. If the tools used should be terminated because of high wear or inability to adjust, the owner will be so informed, and its use will be discontinued.

2.9.6.3 System Control

Electronic data processing techniques will be utilized by Instrument Control to ensure the periodic recall of measurement and test equipment for calibration. Overdue equipment will be identified, and formal notification will be issued to the user. Delinquencies over this time will require notification to the user and to the user's subsection manager. Personnel who use the equipment are charged with the responsibility for using only in-calibration equipment. Periodic audits will be conducted in all using areas.

2.9.7 ENVIRONMENTAL REQUIREMENTS

Environmental controls will be imposed where required to maintain accuracy requirements of the calibration measurement processes, articles, and materials.

2.9.8 REMEDIAL AND PREVENTIVE ACTION

Monitoring of the accuracy of all standards and equipment leading to the accuracy of acceptance test and measurement equipment will be conducted as a preventive measure. Remedial action on errors located will be traced back to the deliverable item for re-test and/or correction of the error.

2.10 STAMP CONTROLS

2.10.1 STAMP CONTROL SYSTEM

Inspection stamps will be utilized to indicate the inspection/test status of all ERTS hardware. In cases where the material cannot be stamped, an attached identification tag will be used. In addition, travel tags, manufacturing/inspection planning, and data sheets will be stamped indicating the status of the hardware. Stamping procedures will be in accordance with Quality Assurance Procedure 6.11, "Indication of Inspection/Test Status."

2.10.2 STAMP RESTRICTION

General Electric stamps are designated in accordance with Quality Operating Procedure 6.11, "Indication of Inspection and Test Status."

2.11 HANDLING STORAGE AND SHIPPING

2.11.1 HANDLING AND STORAGE

Existing Department Instructions and Quality Assurance Procedures will be utilized by GE-SS in support of the ERTS Program. These procedures will be reviewed by the responsible Quality Control Component Engineers prior to their implementation and will be available to NASA GSFC for review upon request.

Existing GE-SS Quality Assurance Procedures that apply in this area are as follows:

1. Quality Assurance Procedure 6.7 "Quality Assurance of Systems Testing"
2. Quality Assurance Procedure 10.3 "Preservation, Handling, and Storage of Material"

Quality Control Component Engineering will provide in the inspection planning the requirements necessary to ensure that items are properly packaged and/or provided with the proper containers prior to final acceptance and release to bonded stock and/or storage. Systems Test Support will provide facilities for the storage, control, and protection of GFE Equipment.

2.11.2 PRESERVATION, MARKING AND LABELING, PACKAGING, AND PACKING

Preservation and packaging of articles will be accomplished to ensure against deterioration, corrosion, and damage while the articles are in process of manufacture, transit, and storage, and shall be accomplished in accordance with Quality Assurance Procedures 10.1, "Shipping and Packaging, Control of," and 10.3, "Preservation, Handling, and Storage of Material."

Deliverable hardware shall be packaged in containers. These containers will be designed specifically for the article they are to contain and will take into consideration any unique requirements due to configuration, fragility, and environmental requirements. Product Assurance will monitor the design, fabraication, and use of these containers to the extent afforded to the flight hardware. Components, assemblies, and parts that are shipped separately will be packaged in accordance with the applicable NASA, Military, Federal, Government, GE, or commercial specifications.

2.11.3 SHIPPING

All articles shipped by GE-SS will be inspected by In-process Quality Assurance prior to shipment to assure that: (1) they are completed units, (2) they are adequately packaged and preserved, (3) they are properly identified, and (4) all necessary documentation accompany the articles.

2.11.3.1 Shipment of GFE Hardware

All GFE hardware shipped from GE-SS to either the supplier or NASA, GSFC is to be inspected by Final Assembly Inspection before being sent to shipping. This inspection consists of checking the item for the following:

1. Dust
2. Scratches
3. Finger prints
4. Bent connector pins
5. Overall condition, including dust caps
6. Proper handling/shipping container

Discrepancies found during the preshipment inspection not previously reported on a GSFC Malfunction Report are to be documented on a GSFC Malfunction Report and dispositioned by the responsible GE-SS engineer and NASA prior to shipment.

It will be the responsibility of the Program Office, Systems Test, and/or Systems Test Support to notify Final Assembly Inspection that a GFE item is to be shipped.

When GFE hardware is being returned to the co-contractor at NASA direction, all necessary documentation, including test logs, Malfunction Reports, and inspection data is to be included in the shipment.

Applicable department and quality assurance procedures are: (1) D.I. 4.7, "Shipment Authorization and Control," (2) Quality Assurance Procedures 10.1, "Shipping and Packaging, Control of," and (3) Quality Assurance Procedures 10.2, "Certificate of Compliance on Outgoing Shipments."

2.12 SAMPLING PLANS, SATISTICAL PLANNING, AND ANALYSIS

2.12.1 SAMPLING PLANS

Sampling plans will be utilized only in the Receiving-Inspection Area for fastening devices and for bulk raw materials where samples are destroyed in the process of materials acceptance testing. The sampling plans will be in accordance with MIL-STD-105 and Quality Assurance Procedures 11.1, "Sampling Inspection by Attributes," and 11.2, "Multiple Sampling Inspections by Attributes." Sampling plans will be submitted to the NASA Contracting Officer for review.

2.12.2 STATISTICAL PLANNING AND ANALYSIS

No statistical planning and analysis will be performed on the ERTS program because of the limited quantities of materials.

2.13 GOVERNMENT PROPERTY CONTROL

2.13.1 CONTRACTORS RESPONSIBILITY

2.13.1.1 Inspection of Government Furnished Equipment (GFE) Payload Test Equipment

2.13.1.1.1 GE Space Systems (GE-SS)

GE-SS has implemented the method described below for the receipt, inspection, and processing of Government Furnished Equipment (GFE) to be used on the ERTS Program. Two different types of GFE will be received by GE-SS for use on the ERTS Program: (1) test equipment for use in checking out the payload and payload components and (2) the payload.

2.13.1.1.2 GFE For Use in Testing Payload and Payload Components

Upon receipt of this type of equipment by GE-SS Receiving, a lot report will be prepared by Receiving. The lot report along with the GFE equipment will be routed to Receiving Inspection for inspection per Receiving Inspection planning.

The basis for which inspection planning will be generated for Receiving Inspection of the GFE will be interface agreements and the GE-SS interface drawings. Receiving inspection will consist of the following:

1. Checking mechanical interface dimensions
2. Physical inspection of equipment for damage
3. Availability of required documentation, including:
    a. Drawings and schematics
    b. Test and checkout procedures
    c. Acceptance test data
    d. Dispositioned GSFC Malfunction Reports
4. Inventory and calibration requirements
5. Receipt of proper shipping document (DD1149, DD250, or GSFC 20-4)

When the GFE test equipment is determined to be acceptable by Receiving Inspection, it will be sent to either the ERTS Systems Test Area or to the Instruments and Calibration Laboratory for inventory and calibration as defined by the inspection planning. Drawings, schematics, test procedures, and data will accompany the equipment while at GE-SS facilities.

2.13.1.1.3 Maintenance and Control of GFE Test Equipment at GE-SS

While located at GE-SS facilities, all GFE test equipment will be maintained and preventive maintenance accomplished in accordance with the requirements prescribed for the individual

pieces of equipment. ERTS Systems Test will be responsible for ensuring that the required maintenance program is implemented.

2.13.1.2 Government-Furnished Equipment (GFE) Payload Components

Conformance of the GFE Payload and documentation to the applicable interface agreement and GE-SS interface drawing is to be used as the basis for accepting the Payload.

Upon receipt at GE-SS, a lot report will be generated for each shipment by Receiving. The received GFE will then be forwarded to Receiving Inspection for inspection per Receiving Inspection planning.

GFE and documentation will remain in storage until such time as arrangements have been made to unpack and inspect the GFE with NASA, his authorized representative, and/or the GFE supplier representative.

Receiving inspection planning will be generated for each GFE component. Specific inspection requirements will be based on GE-SS interface drawings, interface agreements, and inputs provided by the GE-SS component/subsystems engineer relative to documentation being provided. As a minimum, Receiving Inspection planning will require the following:

1. Visual examination of component for damage
2. Dimensional check per GE-SS interface drawing
3. Identification of connectors
4. Verification of documentation received to include:
    a. Component data log book
    b. Connector mate/demate log
    c. Calibration data and/or curves
    d. Component operating time summary
    e. GFE supplier drawings and schematics
    f. Test procedures
    g. GFE component specifications
5. Receipt of proper shipping document (DD1149, DD250, or GSFC 20-4)

If the GE-SS interface drawing is not available, Planning will require that dimensions normally defined on the interface drawings be measured and recorded on the inspection data sheet. Acceptability of components received without GE-SS interface drawings will be determined by the responsible component engineer and NASA.

GFE Components for Bench Integration and Flight Subsystems

When verification of documentation received has been completed by Receiving Inspection and recorded on the inspection data sheet, the total package of documentation, including a copy of receiving inspection data and lot report, will be delivered to the ERTS bonded stockroom for retention.

When GFE components are determined to be acceptable, they will be sent to the ERTS Systems Test Bonded Storage Area. Copies of completed receiving inspection planning for each item will be filed by Receiving Inspection.

Final acceptance of the GFE components by GE-SS will be based on successful completion of a bench performance test performed by ERTS Systems Test using GE-SS generated test procedures and the GFE component supplied BTE.

2.13.2 UNSUITABLE GOVERNMENT PROPERTY

If the GFE test equipment is found to be unacceptable per Receiving Inspection planning requirements, a GSFC Malfunction report will be issued by Receiving Inspection and processed by GE.

If the GFE component had been received by GE-SS and returned to the supplier, Receiving Inspection (on its return to GE-SS) will examine the component for physical damage and verify that planned rework was accomplished. Inspection planning for this effort will be specified on the receiving lot report by the quality inspection planner.

APPENDIX 2.A

QUALITY ASSURANCE PROCEDURES CROSS REFERENCE INDEX TO NHB - 5300.4 (1B)

APPENDIX 2.A

QUALITY ASSURANCE PROCEDURES CROSS REFERENCE INDEX TO NHB-5300.4 (1B)

CHAPTER 1: INTRODUCTION

QAP 2.1 NASA Quality Program Documentation

CHAPTER 2: QUALITY PROGRAM MANAGEMENT AND PLANNING

QAP 1.1 Quality Program Management
*1.2 Quality Program Plan
1.3 Quality Audit Program
1.4 Operating Quality Cost Program
1.6 Quality Assurance Procedures, Preparation and Issuance of
1.7 Quality Assurance Directives
13.1 Operator/Inspector Certification Program
13.2 Test Conductor's, Certification of

CHAPTER 3: DESIGN AND DEVELOPMENT CONTROL

QAP 1.5 Contract Review for Program Planning
2.2 Drawing, Specification, Instruction and Change Control
3.1 Pre-Production Quality Planning
3.2 Design Review

CHAPTER 4: IDENTIFICATION AND DATA RETRIEVAL

QAP 2.3 Configuration Assurance Program
3.4 Identification
12.6 Retention and Storage of Product Assurance Records

CHAPTER 5: PROCUREMENT CONTROL

QAP 4.1 Supplier Survey/Selection
4.2 Procurement Documents - Quality Requirements
*4.3 Government Source Inspection
*4.4 Supplier Control/Surveillance Activity
4.5 Receiving Inspection - General
4.6 Supplier Quality Assurance Provisions
4.7 Release of Material's Accepted by Certification and/or Test Results
4.8 Explosive and Radio Active Materials, Control of
4.9 Handling and Processing Material Received on Lot Report
4.10 Supplier Quality Assurance Documentation
4.11 Supplier Quality Rating
4.12 Supplier Failure Analysis Reports

CHAPTER 6: FABRICATION CONTROLS

QAP 6.2 Quality Assurance of Manufacturing Standing Instructions
6.9 Raw Material from Storeroom to Production, Control Of
*6.10 Control of Shelf Life of Organic Materials
6.12 Cleanliness, Control Of
7.2 Certification and Re-examination of Welding Operators
7.3 Hand Soldering, Control Of
7.5 Conversion Coating of Aluminum
7.6 Process Certification Procedure

CHAPTER 7: INSPECTIONS AND TESTS

QAP 3.3 Qualification of Components
6.1 Fabricated Prime Equipment, Planning and Inspection Of
6.3 Component Standing Instructions
6.4 Systems Detailed Test Procedure
6.5 Inspection Performance
6.7 Quality Assurance of Systems Test
7.1 Radiographic Inspection, Control Of
7.4 Penetrant Inspection, Control Of
12.2 Log Books
12.5 Spacecraft Equipment Log Book

CHAPTER 8: NONCONFORMING ARTICLE AND MATERIAL CONTROL

QAP 8.1 Nonconforming Material, Control and Disposition Of
8.2 Material Review Activity with Suppliers
8.3 Scrap, Control Of
*8.4 Material Review Board Operation
8.5 Nonconforming Material within Microelectronics Thick Film Fabrication Operation
12.3 Failure Analysis
12.4 Corrective Action
12.7 Corrective Action within Microelectronics Thick Film Fabrication Operation

CHAPTER 9: METROLOGY CONTROLS

QAP *9.1 Measurement Standards, Control Of
*9.2 Test Equipment Control
9.3 Personally Owned Mechanical Precision Measuring Equipment, Control and Calibration Of
9.4 Gage Wear Policy
9.5 Calibration of Dimensional/Optical Measuring Equipment
9.6 Calibrated Manufacturing Tools, Control Of
9.7 Special Inspection Tooling, Control Of

CHAPTER 9: METROLOGY CONTROLS (Continued)

QAP 9.8 Storage of Equipment, Disposition of Obsolete and Surplus Equipment
6.8 Production Tooling, Quality Assurance Of
6.13 Lofted Templates

CHAPTER 10: STAMP CONTROL

QAP 6.11 Indication of Inspection and Test Status

CHAPTER 11: HANDLING, STORAGE, PRESERVATION, MARKING, LABELLING, PACKAGING, PACKING AND SHIPPING

QAP 10.1 Shipping and Packaging, Control Of
10.2 Certification of Compliance on Outgoing Shipments
10.3 Preservation, Handling and Storage of Material
10.4 Stores Auditing

CHAPTER 12: SAMPLING PLANS, STATISTICAL PLANNING AND ANALYSIS

QAP 11.1 Sampling Inspection by Attributes
11.2 Multiple Sampling Inspection by Attributes

CHAPTER 13: GOVERNMENT PROPERTY CONTROL

QAP 5.1 Quality Control of Government Furnished Material
5.2 Quality Control of Government - Owned Special Tooling and Special Test Equipment
5.3 Military Property, Quality Control Of
5.4 Industrial Equipment Modernization and Replacement Program
5.5 Damaged Government Property

APPENDIX 2. B

GE QUALITY ASSURANCE PROCEDURES

Two copies of GE Quality Assurance Procedures are submitted as a part of this study report. They are included with other separately bound documentation.

APPENDIX 2. C

TEST MONITOR AND CONTROL PLAN

APPENDIX 2.C

TEST MONITOR AND CONTROL PLAN

2.C.1 GENERAL

The Earth Resources Technology Satellite Test Program is based on the application of proven methods and controls demonstrated by GE on the NASA Goddard Space Flight Center Nimbus, OAO, and OSO Programs; JPL - Mariner; and Air Force space programs. This test monitor and control plan is a prime feature of program performance assurance. It has been effectively integrated with the reliability plan, the quality plan, and the configuration management plan which comprise basic elements of the Earth Resources Technology Satellite Assurance Program.

2.C.1.1 TEST PROGRAM

The test program is planned, using the building block all-up test method, to ascertain and demonstrate readiness of the flight spacecraft system to carry out its intended mission. This is accomplished by the utilization of proven, qualified design, careful, error-free workmanship, and positive deficiency correction.

2.C.1.2 CONTROL

General Electric will implement test monitor and control functions in accordance with policies, procedures, and assigned responsibilities described herein. These test plans include piece part and material testing and control, component testing, subsystem testing, and testing of the integrated spacecraft system.

Comprehensive functional performance and environmental testing will be conducted and controlled at all levels. Development testing on new designs will be conducted to establish design adequacy. Qualification testing to design specifications will follow. Acceptance testing and control of all flight units and flight spares will be conducted. Documentation of test data and comprehensive evaluation of data will be made to assure that in the test program, design intent and specification requirements are met.

2.C.2 INTEGRATED TEST PROGRAM BOARD

To implement management and control functions over the entire spectrum of Earth Resources Technology Satellite spacecraft tests, General Electric will utilize an Integrated Test Program Board consisting of representatives from Earth Resources Technology Satellite Program Management, Earth Resources Technology Satellite Test Operations, Research and Engineering, and Performance Assurance. The Chairman of the Integrated Test Program Board will be the Manager, Earth Resources Technology Satellite Performance Assurance, who will be the designated representative of the Earth Resources Technology Satellite Program Manager. The prime purpose of this board will be to assure adherence of all conducted

tests to the planned integrated test program, analyze qualification test results, award qualification status where applicable, and analyze acceptance test data to ascertain compliance to acceptance test criteria.

This function will be extended to the review and approval of major subcontract test results.

The Integrated Test Program Board will analyze test results for awarding of qualification or acceptance test status, taking into consideration such factors as configuration of the article under test, configuration of test setup, certification of completed inspections, and compliance of test procedures to the component, subsystem, and/or system specification.

2.C.2.1 INTEGRATED TEST PLAN FOR EARTH RESOURCES TECHNOLOGY SATELLITE

The comprehensive test plan for Earth Resources Technology Satellite is fully described in the Integrated Test Plan, Volume IIA of the Technical Proposal. This plan depicts the test program, sequence, and schedule designed to demonstrate that the hardware and software are ready for mission attainment. The test schedule involves a simultaneous sequence of development and engineering tests, specified component qualification and component acceptance testing, subsystems bench integration testing, subsystem integration for the flight systems, and full systems testing. Continuous attention is required to provide effective performance assurance. The basic operational control documents are the test plans and test procedures which clearly specify the sequence, the limits, the data, and all pertinent required features of the test.

2.C.2.2 ITPB DETAIL RESPONSIBILITIES

In providing a control on the Integrated Test Program, the ITPB will carry out these responsibilities:

1. Review all qualification specifications and test procedures to determine agreement with program requirements and verify that such documents form a valid basis for qualification.
2. Review qualification and requalification test data for compliance with program requirements and confer or withhold qualification accordingly.
3. Review failure reports, failure analyses and design changes (AN's) to assess the effect on qualification status.
4. Where qualification is withheld or in the case of qualification withdrawal, recommend action to attain qualification status.
5. Previously qualified designs will be used. When these designs are modified for use on Earth Resources Technology Satellite, the ITPB will evaluate the extent of requalification required.
6. Review all acceptance specifications and test procedures to determine agreement with program requirements and verify that such documents form a valid basis for acceptance.

2.C.3 DEVELOPMENT TEST

A structural dynamic and thermal model will be used to determine and demonstrate structural integrity. The proven concept of bench integrated testing will also apply. This permits integration of new design components with proven design components using non-flight hardware to prove the new spacecraft design and to measure the performance of components and subsystems. Inspection personnel will witness this testing phase.

2.C.3.1 BENCH INTEGRATED TESTING (BIT)

This testing phase, development in nature, is used to perform initial functional integration of new design components at ambient conditions with other proven design components and to integrate combinations of subsystems, components, or complete subsystems. Non-flight items are normally used for the BIT, since qualification and acceptance verification is not the objective. This testing phase is planned by Engineering and conducted by the Earth Resources Technology Satellite Systems Test team.

2.C.3.2 PERFORMANCE ASSURANCE

Performance assurance will monitor this BIT testing activity, to review the test sequence, test setup, and test results. This technical familiarity with the development test program will be extended into component qualification and acceptance testing, and will permit timely preparation of the test plans and procedures.

2.C.4 PARTS TESTING

Effective control and accomplishment of the Earth Resources Technology Satellite Test Program begins at the piece part level. This test level is planned, implemented, and controlled by General Electric.

2.C.4.1 PROCUREMENT AND TESTING

A quality requirement is the procurement of high reliability parts, in agreement with issued GE drawings. Complete test procedures are prepared, issued, and controlled to existing procedures. Upon receipt of the piece parts, selective screening and parameter testing is conducted. A complete record of this testing is developed and maintained. To provide immediate and comprehensive data recording and permit subsequent review and analysis, automated recording techniques are applied using either digital-punched cards or magnetic tape. With the use of an available computer software program, computer print-outs and adaptable formats can be provided.

2.C.5 MODULE AND BOARD TESTING

During the fabrication cycle, a comprehensive testing program is conducted for verification of workmanship and functional integrity of the subassemblies. The test sequence is established in Test Procedures prepared and controlled by Performance Assurance. Special test equipment, some available from other programs, is provided and controlled to existing procedures.

2.C.5.1 TEST SEQUENCE

Pre-pot and post-pot testing of the subassemblies is monitored by engineering personnel. Testing is conducted according to the specific requirements of the issued Test Procedure. Troubleshooting of the subassemblies and special test equipment will be directed by Performance Assurance. The recorded data will be reviewed and approved prior to subassembly use.

2.C.6 COMPONENT TEST

Component Test Plans provide directions for the preparation of acceptance tests, witnessing of testing and review of test data with a recommendation of action by the ITPB.

Component testing, at the qualification and acceptance test level, will meet the requirements of Specification S-32-61 and GE Specification SVS-7739. Included are electrical performance, leak detection, temperature operations, vibration, thermal vacuum, and EMI tests.

2.C.6.1 ACCEPTANCE AND QUALIFICATION TESTING

Detailed test procedures identify the components for test by specific number and configuration and will define the requirements for test facilities, support equipment and instrumentation for the test. The test levels, limits, and the format to be used in recording test data will be defined.

Component acceptance testing conducted at GE-VFSC will be monitored by Performance Assurance to verify that all requirements, including calibration status are met and that proper test discipline is maintained. Test data will be verified and approved to assure that documentation is prepared for any rework, repair, of modification occurring during the test.

A complete log book will be maintained for each component documenting the running time, significant events, and troubleshooting activity.

Performance Assurance will review Nonconformance Reports and will assure that proper disposition is accomplished. Instructions will be issued for the disposition and control of the test article. Test results, records, and reports will be verified and approved to insure that they are accurate, complete, and traceable to the tested articles.

Test reports will be prepared and presented to the ITPB with a recommendation for acceptance approval or disapproval.

2.C.6.1.1 Test Equipment

Special test equipment requirements will be identified. This test equipment will be designed and fabricated under the control of existing procedures, which emphasize full utilization of the equipment for qualification and acceptance testing, where feasible. Control of the Test Equipment configuration status and calibration status will be exercised.

2.C.6.2 COMPONENTS TESTED AT SUBCONTRACTOR

The responsible engineering personnel will review and approve the detailed test plans prepared by supplier organizations. The plan will establish all test requirements, including test item identification and configuration, limits and constraints, test facility and equipment features, instrumentation, environmental conditions, and test data format and record. The approved test plan will be the direction to the supplier for the test. The test preparation, setup, and conduct will be monitored by GE personnel to verify that the requirements are satisfied and test discipline is observed. The monitor will approve by signature the test results and records, prepare and sign Nonconformance Reports, and is responsible for proper disposition and remedial action in accordance with the Configuration Management plan. The monitor's signature will verify that test results are accurate, complete, traceable, and available with the test article.

Test results will be evaluated and a recommendation for action made to the ITPB for component disposition and test acceptance.

2.C.6.3 TEST OPERATIONS

Conduct of the testing at GE VFSC will be in compliance with the issued test procedures and will be performed by qualified test personnel. This organization will certify in writing prior to test initiation, the setup, equipment calibration, and facility readiness in compliance with requirements of the test plan.

Test personnel will also conduct the environmental component tests and maintain the equipment and facilities.

2.C.6.4 DATA ANALYSIS

The analysis of component test data and the verification of component acceptance and qualification will be accomplished by Performance Assurance. A final report of the test, including all necessary details and recommended action, will be submitted to the ITPB.

2.C.7 SUBSYSTEMS TESTING

A comprehensive functional test and checkout of the Attitude Control Subsystem and Orbit Adjust Subsystem by the Earth Resources Technology Satellite Test Organization are planned. The test plans and procedures will be reviewed and approved by the Integrated Test Program Board. The test items will be those which have been flight accepted by previous component tests and evaluations.

Inspection will witness the subsystem testing activities and verify that specified conditions of setup and operation are complied with. Subsystem engineering will monitor the subsystem test activities. When components are suspect during subsystem testing, they will be reviewed by the component engineer assigned to that component. He will assist in the detailed investigation and review of the test data. Performance Assurance will review all nonconformance data and will be responsible for follow up through final disposition of the subsystem.

2.C.7.1 ORBIT ADJUST SUBSYSTEM

The Orbit Adjust components and subsystem will be tested through qualification and acceptance at the subcontractor's plant.

The same precepts of test planning and test conduct used by GE will be applied to this subsystem.

The subcontractor-prepared test plans and procedures, individually reviewed, evaluated, and approved by the ITPB, will be the basis for all testing on this subsystem.

The GE personnel who monitor this test activity will have the assigned authority to stop testing until the subcontractor can provide assurance that the tests satisfy the approved procedures and specifications. The surveillance engineer will approve all nonconformance documentation and process if for final disposition. Test data will be reviewed, approved, and compiled into a final test report at the component and subsystem level and submitted to the ITPB with a recommendation for action.

2.C.8 SYSTEMS TESTING OF THE INTEGRATED SPACECRAFT

Ambient and environmental condition testing of the Earth Resources Technology Satellite spacecraft integrated system in launch and orbital configuration will be conducted at GE-VFSC.

2.C.8.1 AMBIENT SYSTEMS TEST

At this test level, functional compatability and operational integrity of the overall hardware system will be demonstrated.

Systems Test Procedures will be prepared, issued and controlled by the Earth Resources Technology Satellite Test Organization with review and approval by the ITPB. These detailed procedures will specify the test vehicle configuration by specific end item number and contain a listing of the ground support equipment. The test sequence will include payload testing, the test levels, tolerance of parameters to be measured, and the method and format of data recording. Handling requirements, safety considerations, cleanliness specifications and operational test discipline and control will also be included. The approved test procedure will be directly followed in the conduct of the test.

Performance Assurance will review the integrated systems test procedures, monitor the tests, and review the test data.

Inspection will witness the systems testing activity and verify that test procedures were followed. Mate/demate records, verification of connections as specified by procedure and drawing, and testing conduct to specified procedure steps and limits will be noted and documented.

Responsible engineering personnel will participate in the disposition of the nonconformance and take action to prevent recurrence.

2.C.8.2 ENVIRONMENTAL TEST - SYSTEMS LEVEL

Earth Resources Technology Satellite system level environmental testing includes sine and random vibration, thermal vacuum, and solar paddle illumination. The special facility considerations, the required facility data transmission and acquisition system, and other special equipment and services for the environmental test program, and the integration for installation of the flight system, AGE and STE into the test facilities according to GE practice, requires specialized engineering attention.

Testing will be conducted in the special test facilities at VFSC.

Complete operational readiness of the spacecraft and facility must be properly established according to standard GE practices. Test operations provide the technical integration and planning to establish these requirements. Test Operations will prepare, checkout, and operate the thermal/vacuum chamber during system test. They will prepare and operate the vibration systems during this testing phase. All work is done in compliance with a System Operational Readiness Procedure. The test operations will attest to the readiness conditions in writing, providing assurance that all requirements have been satisfied. Earth Resources Technology Satellite Systems Test will also verify in writing overall operational readiness before the test activity is initiated.

The Operational Readiness Procedures will be issued as a part of a final Test Program document included as an integral part of the Earth Resources Technology Satellite Spacecraft System Test Procedures. Approval of this procedure by the ITPB is a requirement.

Emergency and safety plans, and preparation of the Facilities resulting from the special needs imposed by environmental test will be included in the Test Procedure and implemented in the test discipline during actual conduct of the test.

Should the safety of the spacecraft, the environmental facility, or test team personnel be in jeopardy during the preparation, checkout, or conduct of the test, a hold or stop action will be taken. The Test Operations individual in charge of the facility system will notify the Earth Resources Technology Satellite System Test Controller, so that STOP or HOLD action may be exercised.

Inspection personnel will monitor these phases of Systems Test. They exercise the same responsibilities and carry out the same functions described in ambient systems testing.

Component engineering personnel will participate in Fault Isolation at the component level; when required on the spacecraft system. They will monitor the nonconformance records and make disposition to prevent reoccurrence. They will also review the test data and results.

2.C.8.3 SYSTEMS TEST REPORTS AND APPROVAL

The Earth Resources Technology Satellite Systems Test Operation will compile the final test reports for the test operations conducted at this integrated subsystem level. These reports, inclusive of all significant events, with running time and test data verification, will be reviewed by the Integrated Test Program Board and approved as appropriate.

2.C.9 PREFLIGHT PREPARATION

Upon satisfactory completion and approval of the complete system test process, the spacecraft system and GSE will be transported to the Western Test Range for launch preparation, countdown, and launch.

Spacecraft handling, setup, and functional and interface confidence demonstration procedures will be prepared in compliance with NASA direction by the Earth Resources Technology Satellite Systems Test Operation. Integration/approval of these procedures will be accomplished by Systems Test Operations.

Inspection personnel will be a part of the GE preflight and launch team. These personnel will witness the GE testing and checkout activities, and verify that the procedures are followed.

Engineering personnel will be on call to assist in checkout and launch pad troubleshooting, if required.

2.C.10 TEST CONFIGURATION CONTROL

The specified test configuration, including all connections, i.e., electrical, pneumatic, fuel, and gas are included in detail in the Approved Test Procedure.

Performance Assurance will verify, document, and attest for every test level that the specified configuration is tested. They will document and include in the significant event logs, all details of configuration alteration.

This information will be accurately provided in full as a part of the Final Test Reports so that positive traceability may be accomplished.

APPENDIX 2.D

QUALITY REQUIREMENTS FOR ERTS SUBCONTRACTORS

APPENDIX 2.D

QUALITY REQUIREMENTS FOR ERTS SUBCONTRACTORS

2.D.1 INTRODUCTION

2.D.1.1 GENERAL

This plan sets forth the quality program requirements for the ERTS A&B flight hardware and related services to be procured under subcontract to General Electric. Lack of compliance with this requirements document shall require immediate corrective action by the subcontractor.

2.D.1.2 RELATION TO OTHER CONTRACT REQUIREMENTS

The quality program requirements set forth in this document shall be satisfied in addition to the detailed requirements of the General Electric Work Statement and subcontract. In the event of inconsistencies between these documents, the provisions of the subcontract and the work statement shall prevail in this stated order.

2.D.1.3 PREROGATIVES OF THE GOVERNMENT AND GENERAL ELECTRIC

The operations and work of the subcontractor and his suppliers are subject to evaluation, review, audit, survey, and inspection by the General Electric Company, the procuring NASA Installation or its designated Government Quality Representatives.

The subcontractor shall provide the above representatives with information, documents, records, reports, materials, reasonable facilities, and other conveniences necessary for the performance of his duties.

2.D.2 APPLICABLE DOCUMENTS

2.D.2.1 GENERAL

The following documents form a part of this plan to the extent specified herein:

1. NASA Quality Publication NHB 5300.4(1B) Quality Program Provisions for Aeronautical and Space Systems Contractors - April 1969.
2. NASA Quality Publication NPC 200-3 Inspection Systems Provisions for Suppliers of Space Materials, Parts, Components, and Services - April 1962.
3. NASA Reliability and Quality Assurance Publication NHB 5300.4(3A) Requirements for Soldered Electrical Connections - May 1968.
4. GSFC Preferred Parts List - PPL-10 Latest Issue.

4. Charts indicating the flow of fabrication and assembly operations and related inspection and test points.

2.D.4 DESIGN AND DEVELOPMENT CONTROLS

2.D.4.1 QUALITY SUPPORT TO DESIGN REVIEWS

Quality Assurance personnel shall participate in design reviews to insure that designs permit and facilitate producibility, repeatability and inspectability and that related quality considerations are obtained.

2.D.4.2 TECHNICAL DOCUMENTS

The Quality Control Engineer shall perform reviews of drawings, specifications, process specifications, test procedures, and engineering and manufacturing plans and procedures. The contractor shall ensure that the above documentation contains adequate requirements for determining and controlling the quality of all items purchased or produced for this component/subsystem.

2.D.4.2.1 Drawing and Change Control

A positive system to ensure control of the "as built to, as designed configuration" of the component shall be implemented by the contractor. This system shall provide in writing for configuration verification inspection at appropriate stages of assembly.

Copies of documentation defined in paragraph 4.2 shall be furnished as stated in the following paragraph.

One reproducible top assembly and component schematic and one set of each drawing specification, etc., shall be supplied to the ERTS Program Office. A drawing tree to the module or circuit board level shall be prepared and submitted as part of the documentation. Once design freeze has been established on the program, all documentation shall come under a change control system. General Electric approval shall be required on all Class I changes. Notice of all changes shall be provided to General Electric.

2.D.4.3 QUALIFICATION TESTS

2.D.4.3.1 Test Articles

Test articles shall be representative of flight or operational articles which are fabricated and assembled in the same manner and to the same configuration. These test articles shall be specifically identified to distinguish from identical articles for flight or operational use. Qualification articles shall not be used for flight unless specifically directed by General Electric. Qualification test procedures shall be prepared and submitted in advance to General Electric ERTS Project Manager for approval.

2.D.4.3.2 New Design

Qualification test of newly designed articles shall be performed in accordance with the applicable component specification.

2.D.4.3.3 Existing Designs

Qualification test of previously qualified components is required only for those articles which have undergone changes in design which General Electric deems to be major. In this case, the subcontract will define the level of testing required.

2.D.4.3.4 Test Notification

For General Electric to witness qualification testing, the subcontractor shall notify General Electric ten working days prior to the planned start of test.

2.D.4.4 IDENTIFICATION AND TRACEABILITY

2.D.4.4.1 General

The subcontractor shall insure the use of an identification and data retrieval system for articles and materials used in the fabrication of the component. This system shall afford detailed identification by manufactures lot number or serial number of parts and materials in the end item.

2.D.4.4.2 Serialization

Serialization shall be instituted at the black box, subsystem and system level.

2.D.5 PROCUREMENT CONTROLS

2.D.5.1 GENERAL

The subcontractor is responsible for the quality of subcontractor purchased articles, materials and services.

2.D.5.2 CONTROL OF PROCUREMENT SOURCES

The subcontractor shall invoke the provisions of NPC 200-3 in their procurement of major parts and materials and shall maintain records of purchase orders and history of receiving inspection results to enable the subcontractor Quality Control Organization to evaluate suppliers performance and request corrective action where necessary.

2.D.5.3 RECEIVING INSPECTION

Parts and materials shall be inspected to instructions prepared by the contractors Quality Control function. These instructions shall include the type of inspection

required, parameters to be tested, etc. The contractor shall define, in his Quality Program Plan, the method and procedures he plans to use. AQL levels or LTPD shall be based on MIL-STD-105D.

2.D.6 FABRICATION CONTROLS

2.D.6.1 GENERAL

The subcontractor shall control fabrication and assembly operations to ensure that characteristics and design criteria specified in the work statement and specification are obtained.

2.D.6.2 MANUFACTURING FLOW PLAN

The subcontractor shall develop and submit a fabrication flow plan as part of the contract documentation. This flow plan will consist of the fabrication operations to be performed, the inspection and tests that will be conducted, and all special processes.

2.D.6.3 MANUFACTURING PROCEDURE, PROCESSES AND STANDARDS

The subcontractor shall submit applicable fabrication procedures, processes, and standards used. Where proprietary items exist, a method of control by the subcontractor's Quality Control function will be defined and controlled by the Quality Program Plan.

2.D.6.4 PRODUCTION TOOLING

Production tooling, jigs, fixtures or other fabrication equipment which control dimensions, contours or location of fabrication operations shall be controlled to ensure initial accuracy and repeatability during usage.

2.D.6.5 ARTICLE AND MATERIAL CONTROL

2.D.6.5.1 Nonconforming Material

The subcontractor shall ensure that only conforming materials and articles are used. Material or articles not conforming or not required for the operation involved shall be removed from the work areas.

2.D.6.5.2 Limited Life Material

Materials or articles having characteristics of quality degradation with age or use shall be marked to indicate the data the critical life was initiated and will be expended. Materials or articles with limited life shall not be used unless adequate life will remain for subsequent periods of fabrication, storage, and operation. The remaining limited life shall be recorded and supplied as part of the shipping documentation.

2.D.6.6 CLEANLINESS CONTROL

Fabrication, assembly, inspection and test areas shall be controlled to meet the requirements of the component specification.

2.D.6.7 SOLDERING

The provisions of NHB 5300.4(3A) shall apply to all hand soldering operations.

2.D.6.8 CERTIFICATION OF PERSONNEL

Certification of personnel controlling or performing special processes, or fabrication and inspection operations of a specialized nature shall be made by the subcontractor, to ensure the proficiency of each individual. Periodic evaluation and recertification shall be instituted to assure sustained proficiency.

2.D.7 INSPECTION AND TEST

2.D.7.1 GENERAL

The subcontractor shall plan and conduct an inspection and test program which demonstrates that all requirements of the specification and drawings are met.

2.D.7.2 INSPECTION AND TEST PROCEDURES

The subcontractor shall prepare detailed written inspection and test procedures to be used by subcontractor inspection personnel to verify the quality of fabricated articles. This planning shall be made available, upon request, to General Electric for review. This planning shall be maintained current with engineering changes.

2.D.7.3 IN PROCESS INSPECTION

A flow chart of fabrication steps shall be prepared with inspection stations clearly indicated. Written inspection procedures will be required at each of the inspection stations to enable verification of the quality of the fabricated article by the inspector.

2.D.7.4 END ITEM TEST AND FINAL INSPECTION

Acceptance test procedures shall be prepared and submitted 30 days in advance of tests to the General Electric ERTS Project Office for approval. Delivery of the component shall be accompanied by the detailed acceptance test data and all waivers or deviations from nominal conditions.

2.D.8 NONCONFORMING ARTICLES AND MATERIAL CONTROL

2.D.8.1 GENERAL

When an article or material does not conform to applicable drawings, specifications or other requirements, it shall be identified as nonconforming, segregated from the work flow cycle and held for review action.

2.D.8.2 FAILURE REPORTING

All failures occurring during assembly, in process tests, qualification tests or flight acceptance tests shall be reported. Reports shall be made on General Electric approved failure report format. Reports shall be transmitted to General Electric VFSC within 48 hours of its issuance.

2.D.8.3 FAILURE ANALYSES

Failure analyses shall be performed when determined jointly between the subcontractor and the General Electric Program Manager.

2.D.8.4 MATERIAL REVIEW

Unless the material review function is specifically delegated by General Electric and NASA-GSFC to the subcontractor, the limits of subcontractor material review authority shall be for obvious scrap, rework for missing operations, or return to vendor. All other dispositions (i.e. rework not-to-drawing, use-as-is) shall require documentation and submittal to General Electric for review and final dispositioning.

2.D.9 CALIBRATION OF TEST EQUIPMENT

2.D.9.1 GENERAL

Test equipment shall be calibrated at scheduled intervals against a recognized primary or secondary standard. Tags and stickers indicating the data of calibration, expiration date, and signature of the calibrator shall be attached to the equipment as evidence of calibration. Primary or secondary standards shall be traceable to the National Bureau of Standards.

2.D.9.2 METHODS

Equipment calibration methods shall be defined in the subcontractor Quality Plan or by reference to existing subcontractor system.

2.D.10 INSPECTION STAMPS

2.D.10.1 GENERAL

The subcontractor shall implement a system of inspection stamps to be used by inspection personnel as evidence of inspections performed.

2.D.10.2 STAMP CONTROL

Unique designs shall be used to differentiate between fabrication and inspection processes and shall be traceable to the individual responsible for their use.

2.D.10.3 METHODS

Inspection stamp system shall be defined in the subcontractor Quality Plan or by reference to an existing subcontractor system.

2.D.11 PARTS AND MATERIALS SELECTION PROGRAM

2.D.11.1 GENERAL

The subcontractor shall establish a parts and material list for use on the ERTS A&B Program. GSFC Preferred Parts List PPL-10, July 1968, and subcontractor generated PPL, which references high reliability or military parts specifications shall be used as a basis for establishing the program requirements.

2.D.11.2 PARTS LIST APPROVAL

The subcontractor PPL shall be submitted to General Electric for approval prior to use. Copies of manufacturers data sheets shall be forwarded, when available, to aid in identifying the part type and its characteristics. Applicable military specifications need not be submitted, but shall be referenced as the governing documents in the procurement of parts, if applicable. Nonstandard parts require approval and may be approved upon submittal in duplicate of a subcontractor generated nonstandard parts approval request form. Information supplied by the contractor as a minimum shall include:

1. Component/subsystem designation
2. Circuit reference symbol
3. Contractor and contract number
4. Parts description
5. Subcontractor drawing number of part (include drawing in submittal)
6. Actual manufacturer of the part (including standard military parts)
7. Manufacturer's part number
8. Screening to be performed and by whom

9. prior approval history on other NASA or DOD Programs (if known)
10. Comparison between nonstandard part and standard part when characteristics are nearest to those required for the application.
11. Test data and comments (attach as necessary)
12. Certification of accuracy of above by the subcontractor
13. Provision for acceptance by General Electric according to the following: "These data (are/are not) acceptable to General Electric".
14. Signature block and date for General Electric approval

2.D.12 EQUIPMENT LOGS

2.D.12.1 GENERAL

The subcontractor shall establish and maintain a separate log for each component or subsystem end-item as a means of documenting the continuous manufacturing, test and inspection history. Logs shall be identified to the equipment to which they pertain, shall be maintained in chronological order, and shall account for all periods of time including idle periods and any movements of the item.

2.D.12.2 ENTRIES

Entries shall be complete, self-explanatory and include, but not be limited to the following:

1. Date and time entry
2. Identity of test or inspection
3. Environmental conditions
4. Characteristics being investigated
5. Parameter measured
6. Complete identification of instrumentation used including serial number and calibration date.
7. Failure observations and failure report reference
8. Accumulated operating time
9. Mate-demate counts
10. Cumulative number of duty cycles to date
11. Discrepancies between item tested and pertinent specifications or drawings
12. Repair and maintenance record
13. MRB actions
14. Identity of individual making entry

2.D.13 CONFIGURATION CONTROL

2.D.13.1 GENERAL

The subcontractor shall build to applicable specifications delineating performance requirements, interface, design, and construction requirements, and quality verification requirements. These specifications and specific subcontractor drawings shall be used to establish a baseline for configuration control. The subcontractor, as a part of the Quality Program Plan for this procurement, shall define the implementation.

2.D.13.2 ESTABLISHMENT OF DOCUMENTATION BASELINE

Prior to the start of fabrication of deliverable hardware, General Electric with the subcontractor, will review design analysis and design documentation with respect to specified requirements and identify specific design documentation for baseline purposes. Documentation will include schematic wiring diagrams, interconnection diagrams and tables, assembly drawings, parts lists, test procedures, specifications, and similar documents sensitive to Class I changes.

2.D.13.3 CONFIGURATION DEFINITION

1. The supplier shall submit a Configured Article List (black box level) to General Electric at the time of Configuration Freeze.
2. The supplier shall maintain the Configured Article List current after the Configuration Freeze.
3. The Configured Article List shall include the following:
   a. Contractor (name of contractor who is cognizant of the end item).
   b. Specification number
   c. End item nomenclature
   d. Part number
   e. Drawing number including latest change date (this may be the same as the part number).
   f. Serial number
   g. Identification (title, number and date) of test plan
   h. Intended use (prototype, flight or spare)

2.D.13.4 POST BASELINE DOCUMENT CONTROL

The control of changes against the negotiated baseline will be a joint subcontractor/ General Electric activity. The subcontractor shall establish an internal Configuration Control Board (or equivalent) in order to:

1. Review and evaluate internally proposed changes.
2. Approve internal Class II changes (subject to General Electric review).
3. Prepare and forward Engineering Change Proposals to General Electric for approval of all Class I changes.
4. Define a system to monitor the recording and updating of drawings to reflect all approved changes.
5. Provide General Electric with change information and action taken on approved Class II changes.
6. Define a system to provide General Electric with baseline drawings and drawing incorporation of changes.

2.D.13.5 PRODUCT CONFIGURATION COMPLIANCE WITH BASELINE

An audit system shall be established by the subcontractor to assure that compliance with the General Electric/Subcontractor baseline is reflected in the subcontractor's planning, processing, assembly, and test equipment. General Electric will audit, on a periodic basis, with a final configuration audit at the subcontractor's facility before acceptance.

2.D.13.6 CONFIGURATION ACCOUNTING

With each delivered item of flight equipment, the subcontractor shall provide in addition to the log book, a list of applicable documentation identifying the specific change level incorporated in the equipment.

2.D.13.7 DRAWINGS

Drawings for the ERTS Program are to meet MIL-D-1000.

1. New drawings for the ERTS Program shall be made in accordance with MIL-D-1000, Form 2.
2. Existing engineering data shall not be redrawn to meet MIL-D-1000 provided data conforms to all of the following:
   a. Drawings were prepared prior to the date of the invitation to bid or purchase order.
   b. Drawings contain engineering definition adequate to meet the purpose for which the data are required.

c. Drawings define symbols and abbreviations.

d. Drawings will provide legible reproducibles if required by the purchase order.

NOTE: If any of the above provisions are not met, the engineering data shall be redrawn.

3. The supplier shall use the FSCM code identification number assigned to him on all ERTS Program drawings, nameplates, and other documents for which indentification of design activity is required.

2.D.B SUBCONTRACTOR QUALITY PLAN FORMAT

The subcontractor shall prepare a Quality Plan which describes how the subcontractor will insure compliance with the cited quality requirements of this plan.

2.D.B.1 SUGGESTED FORMAT

1. Applicable Documents
2. General
3. Publications
4. Design and Development Controls
5. Procurement Controls
6. Fabrication Controls
7. Inspection and Test
8. Nonconforming Material and Control, and Corrective Action
9. Calibration of Test Equipment
10. Inspection Stamps
11. Parts and Materials Selection
12. Equipment Logs
13. Configuration Control

2.D.A DOCUMENTATION MATRIX

This matrix is for General Electric approval, review or information.

Paragraph Reference		Review	Approval	Information
3.2	Quality Plan		X	
4.2	Technical Documents Review			X
4.3	Qualification Test Procedures and Report		X	
4.3	Test Notification			X
6.2	Manufacturing Flow Plan	X		
6.3	Fabrication Procedures	X		
7.2	Inspection and Test Procedures	X		
7.4	Acceptance Test Procedures and Report		X	
8.2	Failure Report Format		X	
8.2	Failure Reports	X		
8.4	MRB Requirements		X	
11.2	Proposed Parts List		X	
11.2	Nonstandard Parts List		X	
12.1	Logs			X
13.3	Configured Article List	X		
13.6	Change Documentation		X	
13.7	Quality Assurance Operating Procedures		X	
	Bi-Monthly Product Assurance Status Reports (Part of Monthly Progress Report)			X

2.D.C GLOSSARY OF TERMS

The following definitions apply to terms used in this specification:

Class I Change	-	All changes that affect performance, specified design/ construction requirements, or interface relationships.
Class II Change	-	All changes not in the Class I category.
Acceptance	-	The act of an authorized representative of the General Electric Company by which the General Electric Company assents to ownership of existing and identified articles, or approves specific services rendered as partial or complete performance of the contract.
Characteristic	-	Any dimensional, visual, functional mechanical, electrical, chemical, physical, or material feature or property; and any process control element which describes and establishes the design, fabrication, and operating requirements of an article.
Article	-	A unit of hardware or any portion thereof required by the contract.
Component	-	A part, assembly, or combination of parts, subassemblies, or assemblies mounted together to perform a design function.
Deviation	-	A specific authorization, granted before the fact, to depart from a specific requirement.
Interface	-	The junction points or the points within or between systems, subsystems or components where matching or interconnections must be properly achieved in order to make their operation compatible with the successful operation of all other functional entities in the spacecraft or its ground support.
Part	-	One piece, or two or more pieces joined together, which are not normally subject to disassembly without destruction of design use.
Subcontractor	-	The individual (s) or concern (s) who enter into a contract or purchase order under a General Electric contract.
Supplier	-	A contractor or subcontractor actually performing the services or producing the contract articles.
Waiver	-	Granted use or acceptance of an article which does not meet specified requirements.

APPENDIX 2.E

ERTS PROPOSAL HARDWARE VERSUS QUALITY FUNCTION

Payload Subsystem	Quality Assurance Engineering																								Config. Mgmt. and Inspection			Test Operations		Equipment Eng'g		Microelectronics and Process Control Eng'g					
	Make = M Buy = B	Design Status: N = New M = Mod Nimbus, I = Nimbus, FP = Flight Proven	MRB Representation	Support Design Reviews	Provide Insp. Planning	Provide Test Procedures	Provide Test Equip. Reqm't's	Support Vendor Selection	Provide Vendor Quality Reqm't's	Support Testing	Provide ITPB Representation	Conduct Vendor and MSC Quality Surv.	Provide Vendor Surveillance	Provide Rec'v'g Inspection	Provide CCB Representation	Review Drawings	Review Specifications	Review Test Results	Review Failure Data	Support Failure Corrective Action	Perform Failure Analysis	Procurement Support	Support Mfg.	Perform In-Process Inspection	Perform Final Inspection	Prepare Log Books	Perform Testing	Perform Operations Control	Provide Special Test Equip.	Maintain Special Test Equip.	Perform Parts Insp. and Testing	Perform Raw Mat'l Acceptance	Provide Process Control Eng'g	Monitor Contamination Controls	Control Material Processes	Provide Parts Application Eng'g
RBVS	-	-	-	-	QF	-	-	-	-	-	-	-	-	QF	-	-	-	-	-	-	-	-	-	-	-	-	QF	-	-	-	-	-	-	-
MSS	-	-	-	-	QF	-	-	-	-	-	-	-	-	QF	-	-	-	-	-	-	-	-	-	-	-	-	QF	-	-	-	-	-	-	-
WBVTR	-	-	-	-	QF	-	-	-	-	-	-	-	-	QF	-	-	-	-	-	-	-	-	-	-	-	-	QF	-	-	-	-	-	-	-
DCS	-	-	-	-	QF	-	-	-	-	-	-	-	-	QF	-	-	-	-	-	-	-	-	-	-	-	-	QF	-	-	-	-	-	-	-

Key

D = Development
Q = Qualification
F = Flight and Spare
E = Existing

Attitude Control Subsystem	Quality Assurance Engineering																							Config. mgmt, and Inspection			Test Operations		Equipment Eng'g		Microelectronics and Process Control Eng'g					
	Make = M Buy = B	Design Status: N = New M = Mod Nimbus, I = Nimbus, FP = Flt Proven	MRB Representation	Support Design Reviews	Provide Insp. Planning	Provide Test Procedures	Provide Test Equip. Reqm'ts	Support Vendor Selection	Provide Vendor Quality Reqm'ts	Support Testing	Provide ITPB Representation	Conduct Vendor and MSC Quality Survey	Provide Vendor Surveillance	Provide Rec'v'g Inspection	Provide CCB Representation	Review Drawings	Review Specifications	Review Test Results	Review Failure Data	Support Failure Corrective Action	Perform Failure Analysis	Procurement Support	Support Mfg.	Perform In-Process Inspection	Perform Final Inspection	Prepare Log Books	Perform Testing	Perform Operations Control	Provide Special Test Equip.	Maintain Special Test Equipment	Perform Parts Insp. and Testing	Perform Raw Mat'l Acceptance	Provide Process Control Eng'g.	Monitor Contamination Controls	Control Material Processes	Provide Parts Application Eng'g.
Structure	B	M	F	-	F	-	-	-	F	F	F	-	F	F	F	-	-	-	-	-	F	F	-	-	-	-	-	F	-	-	-	-	-	-	-
Therm. Control Assy.	B	I	F	-	F	-	-	-	F	F	F	-	F	F	F	-	F	F	F	F	F	F	-	-	-	-	-	F	-	-	-	-	-	-	-
Pitch Flywheel	B	I	F	-	F	-	-	-	F	F	F	-	F	F	F	-	F	F	F	F	F	F	-	-	-	-	-	F	-	-	-	-	-	-	-
Yaw Flywheel	B	I	F	-	F	-	-	-	F	F	F	-	F	F	F	-	F	F	F	F	F	F	-	-	-	-	-	F	-	-	-	-	-	-	-
Pneumatics Assy.	B	I	F	-	F	-	-	-	F	F	F	-	F	F	F	-	F	F	F	F	F	F	-	-	-	-	-	F	-	-	-	-	-	-	-
Solar Array Drive	B	I	F	-	F	-	-	-	F	F	F	-	F	F	F	-	F	F	F	F	F	F	-	-	-	-	-	F	-	-	-	-	-	-	-
Rate Measuring Pkg.	B	I	F	-	F	-	-	-	F	F	F	-	F	F	F	-	F	F	F	F	F	F	-	-	-	-	-	F	-	-	-	-	-	-	-
Yaw Rate Gyro	B	I	F	-	F	-	-	-	F	F	F	-	F	F	F	-	F	F	F	F	F	F	-	-	-	-	-	F	-	-	-	-	-	-	-
Mag. Moment Assy.	B	I	F	-	F	-	-	-	F	F	F	-	F	F	F	-	F	F	F	F	F	F	-	-	-	-	-	F	-	-	-	-	-	-	-
Roll Reach. Whl. Scan	B	I	F	-	F	-	-	-	F	F	F	-	F	F	F	-	F	F	F	F	F	F	-	-	-	-	-	F	-	-	-	-	-	-	-
Control Logic Box	B	M	QF	DQ	QF	-	-	-	Q	QF	QF	-	QF	QF	QF	-	QF	QF	QF	QF	QF	QF	-	-	-	-	-	QF	-	-	-	-	-	-	-
Signal Processor	B	I	Fc	-	F	-	-	-	F	F	F	-	F	F	F	-	F	F	F	F	F	F	-	-	-	-	-	F	-	-	-	-	-	-	-
Initiation Timer	B	I	F	-	F	-	-	-	F	F	F	-	F	F	F	-	F	F	F	F	F	F	-	-	-	-	-	F	-	-	-	-	-	-	-
Attitude Sensor	B	N	QF	-	F	-	-	-	F	F	F	-	F	F	F	-	F	F	F	F	F	F	-	-	-	-	-	F	-	-	-	-	-	-	-
Insulation	B	M	F	-	F	-	-	-	F	F	F	-	F	F	F	-	F	F	F	F	F	F	-	F	F	-	-	F	-	-	F	F	-	-	-

Key

D = Development
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Structure Subsystem	Quality Assurance Engineering																									Config. Mgmt. and Inspection			Test Operations		Equipment Eng'g		Microelectronics and Process Control Eng'g					
	Make = M Buy = B	Design Status: N = New, M = Mod Nimbus, I = Nimbus FF = Flt. Proven	MRB Representation	Support Design Reviews	Provide Insp. Planning	Provide Test Procedures	Provide Test Equip. Reqm'ts	Support Vendor Selection	Provide Vendor Quality Reqm'ts	Support Testing	Provide ITPB Representation	Conduct Vendor and MSC Quality Survey	Provide Vendor Surveillance	Provide Rec'v'g Inspection	Provide CCB Representation	Review Drawings	Review Specifications	Review Test Results	Review Failure Data	Support Failure Corrective Action	Perform Failure Analysis	Procurement Support	Support Mfg.	Perform In-Process Inspection	Perform Final Inspection	Prepare Log Books	Perform Testing	Perform Operations Control	Provide Special Test Equip.	Maintain Special Test Equip.	Perform Parts Insp. and Testing	Perform Raw Mat'l. Acceptance	Provide Process Control Eng'g.	Monitor Contamination Controls	Control Material Processes	Provide Parts Application Eng'g.
Torus Ring Struct.	M	M	F	-	F	-	-	-	F	-	-	-	F	F	F	F	-	-	-	-	-	F	F	F	F	-	-	F	-	-	F	F	-	F	-
Cross Beam	M	N	F	-	F	-	-	-	-	-	-	-	-	F	F	F	-	-	-	-	-	F	F	F	F	-	-	-	-	-	F	F	-	F	-
Sensor Mounts	M	N	F	-	F	-	-	-	-	-	-	-	-	F	F	F	-	-	-	-	-	F	F	F	F	-	-	-	-	-	F	F	-	F	-
Antenna Mounts	M	N	F	-	F	-	-	-	-	-	-	-	-	F	F	F	-	-	-	-	-	F	F	F	F	-	-	-	-	-	F	F	-	F	-
Harness Sup't Struct.	M	N	F	-	F	-	-	-	-	-	-	-	-	F	F	F	-	-	-	-	-	F	F	F	F	-	-	-	-	-	F	F	-	F	-
ERTS/ACS Interface Pan.	M	I	F	-	F	-	-	-	-	-	-	-	-	F	F	F	-	-	-	-	-	F	F	F	F	-	-	-	-	-	F	F	-	F	-
Paddle Damper	M	I	F	-	F	F	-	-	-	F	F	-	-	F	F	F	F	F	F	F	F	F	F	F	F	F	F	E	F	-	F	F	F	F	-
Separation Switch	M	I	F	-	F	F	-	-	-	F	F	-	-	F	F	F	F	F	F	F	F	F	F	F	F	F	F	E	F	-	-	-	-	F	-
Paddle Latch Hdwre.	M	I	F	-	F	-	-	-	-	-	-	-	-	F	F	F	-	-	-	-	-	-	F	F	F	-	-	-	-	-	F	F	-	F	-
Paddle Unfold. Sw.	M	I	F	-	F	F	-	-	-	F	F	-	-	F	F	F	F	F	F	F	F	F	F	F	F	F	F	E	F	-	-	-	-	F	-
Cable Cutter and Squib	B	I	F	-	F	F	-	-	F	F	F	-	F	F	F	F	F	F	F	F	F	F	-	-	-	-	-	-	F	-	-	-	-	-	-
Struts	M	I	F	-	F	-	-	-	-	-	-	-	F	F	F	F	-	-	-	-	-	F	-	-	-	-	-	-	F	-	-	-	-	-	-
Load Cells	M	I	F	-	F	F	-	-	-	F	F	-	-	F	F	F	-	F	F	F	F	-	F	F	F	F	F	E	F	-	F	F	-	F	-
Paddle Latch Cable	M	I	F	-	F	-	-	-	-	-	-	-	F	F	F	F	-	-	-	-	-	F	-	-	-	-	-	-	F	-	-	-	-	-	-
Bolt Cutter and Pyro	B	I	F	-	F	F	-	-	F	F	F	-	F	F	F	F	F	F	F	F	F	F	-	-	-	-	-	-	F	-	-	-	-	-	-
Adapter Prim. Struct.	M	M	F	-	F	-	-	-	F	-	-	-	F	F	F	F	-	-	-	-	-	F	-	-	-	-	-	-	F	-	-	-	-	-	-
Adapter Secn. Struct.	M	N	F	-	F	-	-	-	-	-	-	-	-	F	F	F	-	-	-	-	-	-	F	F	F	-	-	-	-	-	F	F	-	F	-
Sep'n Band Assy.	M	I	F	-	F	-	-	-	-	-	-	-	F	F	F	F	-	-	-	-	-	F	-	-	-	-	-	-	F	-	-	-	-	-	-
Separation Springs	B	N	F	-	F	F	F	-	-	F	-	-	F	F	F	F	-	F	F	F	F	F	-	-	F	F	F	F	F	-	-	-	-	-	-
Cmd. Ant. Low. Gnd. Pln.	B	M	F	-	F	-	-	-	-	-	-	-	F	F	F	F	-	-	-	-	-	F	-	-	-	-	-	-	F	-	-	-	-	-	-
WB Ant. Pickup and Re-Rad	M	N	F	-	F	F	-	-	-	F	F	-	-	F	F	-	-	F	F	F	F	-	F	F	F	F	F	-	F	-	F	F	-	F	-
Un'd S-Band Ant. P.U. and R.R.	M	N	F	-	F	F	-	-	-	F	F	-	-	F	F	-	-	F	F	F	F	-	F	F	F	F	F	-	F	-	F	F	-	F	-

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Orbit Adjust Subsystem	Quality Assurance Engineering																								Config. Mgmt. & Inspection			Test Operations		Equipment Eng'g		Microelectronics and Process Control Eng'g					
	Make = M Buy = B	Design Status: N = New M = Mod Nimbus, I = Nimbus, FP = Flight Proven	MRB Representation	Support Design Reviews	Provide Insp. Planning	Provide Test Procedures	Provide Test Equip. Regm'ts	Support Vendor Selection	Provide Vendor Quality Regm'ts	Support Testing	Provide ITPB Representation	Conduct Vendor and MSC Quality Surv.	Provide Vendor Surveillance	Provide Rec'v'g Inspection	Provide CCB Representation	Review Drawing	Review Specifications	Review Test Results	Review Failure Data	Support Failure Corrective Action	Perform Failure Analysis	Procurement Support	Support Mfg	Perform In-Process Inspection	Perform Final Inspection	Prepare Log Books	Perform Testing	Perform Operations Control	Provide Special Test Equip	Maintain Special Test Equip	Perform Parts Insp. and Testing	Perform Raw Mat'l Acceptance	Provide Process Control Eng'g	Monitor Contamination Controls	Control Material Processes	Provide Parts Application Eng'g
Propellant Tank	B	FP	QF	QF	QF	-	-	-	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	-	-	-	-	-	QF	-	-	-	-	-	-	-
Thruster	B	FP	QF	QF	QF	-	-	-	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	-	-	-	-	-	QF	-	-	-	-	-	-	-
NC Exp Value	B	FP	QF	QF	QF	-	-	-	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	-	-	-	-	-	QF	-	-	-	-	-	-	-
NO Exp Valve	B	FP	QF	QF	QF	-	-	-	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	-	-	-	-	-	QF	-	-	-	-	-	-	-
Fill Valves	B	FP	QF	QF	QF	-	-	-	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	-	-	-	-	-	QF	-	-	-	-	-	-	-
System Test Valve	B	FP	QF	QF	QF	-	-	-	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	-	-	-	-	-	QF	-	-	-	-	-	-	-
Filter	B	FP	QF	QF	QF	-	-	-	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	-	-	-	-	-	QF	-	-	-	-	-	-	-
Thruster Valve	B	FP	QF	QF	QF	-	-	-	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	-	-	-	-	-	QF	-	-	-	-	-	-	-
Pressure Transducer	B	FP	QF	QF	QF	-	-	-	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	-	-	-	-	-	QF	-	-	-	-	-	-	-
Temp. Transducer	B	FP	QF	QF	QF	-	-	-	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	QF	-	-	-	-	-	QF	-	-	-	-	-	-	-

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NOTE: Propellant tank will be qualified as a component. Other components will be qualified at subsystem level.

Electrical Integration	Quality Assurance Engineering																							Config. Mgmt. and Inspection			Test Operations		Equipment Eng'g		Microelectronics and Process Control Eng'g					
	Make = M Buy = B	Design Status: N = New M = Mod Nimbus, I = Nimbus, FP = Flight Proven	MRB Representation	Support Design Reviews	Provide Insp. Planning	Provide Test Procedures	Provide Test Equip. Reqm'ts	Support Vendor Selection	Provide Vendor Quality Reqm'ts	Support Testing	Provide ITPB Representation	Conduct Vendor and MSC Quality Survey	Provide Vendor Surveillance	Provide Rec'v'g Inspection	Provide CCB Representation	Review Drawings	Review Specifications	Review Test Results	Review Failure Data	Support Failure Corrective Action	Perform Failure Analysis	Procurement Support	Support Mfg.	Perform In-Process Inspection	Perform Final Inspection	Prepare Log Books	Perform Testing	Perform Operations Control	Provide Special Test Equip.	Maintain Special Test Equip.	Perform Parts Insp. and Testing	Perform Raw Mat'l Acceptance	Provide Process Control Eng'g	Monitor Contamination Controls	Control Material Processes	Provide Parts Application Eng'g
Spacecraft Harness	M	N	QF	DQF	QF	QF	Q	-	-	QF	QF	-	-	QF	QF	Q	Q	QF	QF	QF	QF	-	QF	QF	QF	QF	F	QF	Q	QF	QF	QF	QF	QF	QF	-
Flt. Adapter Harn.	M	M	F	DF	F	F	F	-	-	F	F	-	-	F	F	F	F	F	F	F	F	-	F	F	F	F	-	F	F	F	F	F	F	F	F	-
Antenna Model Harness	M	N	-	-	D	-	-	-	-	D	-	-	-	-	-	-	-	D	-	-	-	-	-	D	D	-	D	D	-	-	-	-	-	-	-	-
ACS Harness	M	M	F	-	F	F	-	-	-	F	F	-	-	F	F	F	F	F	F	F	F	-	F	F	F	F	F	F	-	F	F	F	F	F	F	-
Pwr. Switching Module	M	N	QF	QF	QF	QF	Q	-	-	QF	QF	-	-	QF	QF	Q	Q	QF	QF	QF	QF	-	QF	QF	QF	QF	QF	QF	Q	QF	QF	QF	QF	QF	QF	Q
Preflight Discon.	B	I	F	-	F	-	-	-	F	F	F	-	F	F	F	-	F	F	F	F	-	F	-	-	-	-	-	F	-	-	-	-	-	-	-	-

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Power Subsystem	Quality Assurance Engineering																									Config. Mgmt. and Inspection			Test Operations		Equipment Eng'g		Microelectronics and Process Control Eng'g					
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Solar Paddles	B	I	F	-	F	-	-	-	F	F	F	-	F	F	F	F	F	F	F	F	F	-	-	-	-	-	F	-	-	-	-	-	-	-
Storage Module	B	I	F	-	F	-	-	-	F	F	F	-	F	F	F	F	F	F	F	F	F	-	-	-	-	-	F	-	-	-	-	-	-	-
Power Control Mod.	B	I	F	-	F	-	-	-	F	F	F	-	F	F	F	F	F	F	F	F	F	-	-	-	-	-	F	-	-	-	-	-	-	-
Payload Reg. Mod.	B	I	F	-	F	-	-	-	F	F	F	-	F	F	F	F	F	F	F	F	F	-	-	-	-	-	F	-	-	-	-	-	-	-
Sep. and Unfold Timer	M	I	F	-	F	F	-	-	-	F	F	-	-	F	F	F	F	F	F	F	-	F	F	-	F	F	F	E	-	F	F	F	F	F	-
Aux. Load Panel	M	I	F	-	F	F	-	-	-	F	F	-	-	F	F	F	F	F	F	F	-	F	F	-	F	F	F	E	-	F	F	F	F	F	-
Aux. Load Contr.	M	I	F	-	F	F	-	-	-	F	F	-	-	F	F	F	F	F	F	F	-	F	F	-	F	F	F	E	-	F	F	F	F	F	-

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Communications and Data Handling Subsystem	Quality Assurance Engineering																										Test Operations		Equipment Eng'g		Microelectronics and Process Control Eng'g					
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Command Clock	B	I	F	-	F	-	-	-	F	F	F	-	F	F	F	F	F	F	F	F	F	F	-	-	-	-	-	-	-	-	-	-	-	-	-
VHF Comm. RBC	B	N	QF	DQ	DQF	-	-	D	QF	QF	QF	D	QF	DQF	QF	Q	Q	QF	QF	QF	QF	QF	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VHF Transmitter	B	N	QF	DQ	DQF	-	-	D	QF	QF	QF	D	QF	DQF	QF	Q	Q	QF	QF	QF	QF	QF	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PCM TLM Proc.	B	I	F	-	F	-	-	-	F	F	F	-	F	F	F	F	F	F	F	F	F	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pre Mod Proc.	B	N	QF	DQ	DQF	-	-	D	QF	QF	QF	D	QF	DQF	QF	Q	Q	QF	QF	QF	QF	QF	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Conditioner Box	M	N	QF	DQ	QF	QF	Q	-	-	QF	QF	-	-	DQF	QF	Q	Q	QF	QF	QF	QF	-	QF	QF	QF	QF	QF	QF	Q	QF	QF	QF	QF	-	QF	D
Comm. Integ.	M	N	QF	DQ	QF	QF	Q	-	-	QF	QF	-	-	DQF	QF	Q	Q	QF	QF	QF	QF	-	QF	QF	QF	QF	QF	QF	Q	QF	QF	QF	QF	-	QF	D
N. B. Tape Rec.	B	N	QF	DQ	DQF	-	-	D	QF	QF	QF	D	QF	DQF	QF	Q	Q	QF	QF	QF	QF	QF	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WB Freq. Mod.	B	N	QF	DQ	DQF	-	-	D	QF	QF	QF	D	QF	DQF	QF	Q	Q	QF	QF	QF	QF	QF	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NB Pwr. Amp.	B	N	QF	DQ	DQF	-	-	D	QF	QF	QF	D	QF	DQF	QF	Q	Q	QF	QF	QF	QF	QF	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Filter	B	N	QF	DQ	DQF	-	-	D	QF	QF	QF	D	QF	DQF	QF	Q	Q	QF	QF	QF	QF	QF	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WB Antenna	M	N	QF	DQ	QF	QF	Q	-	-	QF	QF	-	-	QF	QF	Q	Q	QF	QF	QF	QF	-	QF	QF	QF	QF	QF	QF	Q	QF	-	QF	QF	-	-	-
Comm. Ant.	M	I	F	-	F	F	-	-	-	F	F	-	-	F	F	F	F	F	F	F	F	-	F	F	F	F	F	F	E	F	-	F	F	-	-	-
Quad. Ant.	M	I	F	-	F	F	-	-	-	F	F	-	-	F	F	F	F	F	F	F	F	-	F	F	F	F	F	F	E	F	-	F	F	-	-	-
Unif. S-Band Ant.	M	I	F	-	F	F	-	-	-	F	F	-	-	F	F	F	F	F	F	F	F	-	F	F	F	F	F	F	E	F	-	F	F	-	-	-
Unif. S-Band Equip.	B	N	QF	DQ	DQF	-	-	D	QF	QF	QF	D	QF	DQF	QF	Q	Q	QF	QF	QF	QF	QF	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Key

D = Development
Q = Qualification
F = Flight and Spares
E = Existing

SECTION 3

PARTS PLAN

SECTION 3

PARTS PLAN

3.1 GENERAL

The parts plan for ERTS is designed to assure compliance with the requirements of the mission. The plan covers electrical, electronic and electromechanical parts, including microcircuits. The principal criteria for the program include:

1. Select parts based on prior experience.
2. Understand and evaluate part constituent materials and processes.
3. Screen parts used in prime equipment.
4. Select suppliers with proven capability and dependable products.
5. Establish the environments in which the parts will function.
6. Derate parts electrically and thermally.
7. Apply parts in circuits which are tolerant of transients.

Properly used, the parts will function reliably for the life of the mission. The key is to eliminate potential defectives and build with model parts.

The overall GE parts philosophy for evaluation, screening, and control is based on the accumulation of experience and the flexibility needed to meet the program and customer requirements. Reliability procedure 3.11, "Parts and Materials Program", and 1.21, "Parts and Applications Engineering Routine-Method of Operation," indicate the program elements which are available for administering a parts program for application in a space environment.

3.2 PART SELECTION AND APPROVAL

The selection of electrical, electronic and electromechanical parts for use in ERTS is primarily based on the needs of the design. The Parts Application Engineer, working with the individual design engineer, identifies parts which will reliably perform the required functions. The initial selection of parts is made to assure coverage of basic needs (i.e., complementary digital integrated circuits; a range of capacitors, resistors, transistors, diodes, and relays) supplemented by those specific parts which were identified during the study phase.

3.2.1 BASIC PART SELECTION CRITERIA

The criteria used in the selection of parts includes:

1. Optimum physics of construction for space applications.
2. Favorable past history, e.g., Apollo, Nimbus, IDEP (Interagency Data Exchange Program), Alerts, etc.
3. Availability of performance information.
4. Common usage to permit optimum learning, availability, and cost.
5. Availability from a prime part supplier.

3.2.2 APPROVED PARTS LIST

A list of approved parts will be used as the controlling document. This list will consist of parts identified during the study phase supplemented by those parts required for basic coverage. Where possible, parts will be selected consistent with the GSFC Preferred Parts List PPL-10. Where a suitable part is not available on PPL-10, parts will be selected based on the requirements for performance compatability, life and reliability consistent with the ERTS mission. Each part will be identified by either its Military Specification number, the existing specification, or by the need for a part specification.

The approved part supplier for each part will also be identified on the list and the part specification. New parts will be added only when an identified part will not fulfill the actual design need. The addition of new parts will be made only after their need is identified, reviewed and agreed to between the design engineer and the Parts Application Engineer.

The approved parts list will be submitted for review.

3.3 PART SUPPLIERS

The controls and processes used by the part supplier in the manufacture of parts is of prime importance in obtaining reliable parts for use in a space environment. The selection of the part supplier is controlled by the part specification and is based on the following criteria:

1. Reliable part design, materials, and configuration.
2. Experience on part performance.
3. Current production of preferred parts.
4. Military specification qualification (particularly TX and ER parts).
5. In-house established reliability production lines.
6. Well-defined and controlled processes; in-line inspection and controls; quality control system.
7. Recognized technical proficiency.

8. In-house closed loop failure analysis and corrective action system.
9. Effective control of raw material sources.
10. Physical facilities.
11. Financially stable organization.
12. Vendor survey per NASA NPC 200-3.
13. Cost.

The approved supplier for each part is also identified on the list and the part specification. The initial list is minimal in order to encourage standardization of part types. New parts will be added only when an actual design arises. When these new requirements are identified, reviewed, and agreed to, Parts Engineering will prepare or coordinate (for Subcontractors) the required documentation to properly define and control the parts in accordance with the program requirements.

Parts which are listed on the preferred list are items which have been previously qualified for space applications. Qualification is based on:

1. Test data from in-house or subcontractor's test.
2. Test data available from data exchange programs.
3. Test data from part suppliers for other space programs.
4. Experience and history of usage (test, performance, and flight) in spacecraft programs.

3.4 PART PROCUREMENT SPECIFICATIONS

Maximum use will be made of existing part specifications for ERTS. Parts utilized in new designs and modifications of existing designs will be:

1. NASA preferred designation in accordance with PPL-10.
2. Existing GE Specifications.
3. Military Specifications.
4. New Drawings.

When part procurement drawings are prepared, the following elements will be included:

1. Performance, functional parameters and tolerances.
2. Case configuration and mounting details.
3. Materials (directly or by reference).
4. Lead size and weldability requirements.
5. Process and configuration controls.

6. Visual inspection requirements.
7. Environmental requirements.
8. In-line preconditioning and inspection requirements.
9. Qualification and Acceptance Inspection requirements.
10. Screening test requirements.
11. Acceptance and inspection requirements.
12. Part name, type, and manufacturer's identification.
13. Lot identification and traceability requirements.
14. Identification and data provisions.
15. Packaging instructions.

Part specifications will be consistent with the part reliability requirements established by NASA and the NASA preferred parts.

3.5 PART SCREENING AND RELIABILITY TESTING

The test program that will be used for ERTS parts will provide verification that the parts meet the quality standards and characteristics required in the part specification and have the stability required for the mission. Screening tests will be performed on a 100 percent basis to stabilize devices and to eliminate devices which are defective or deviate from normal. The screening test program for each part type is designed and implemented after analysis and understanding the part constituent materials the processor used in the part manufacture, and the degree of control of these processes. The type of tests which will be performed will be in accordance with Appendix C of the GSFC Preferred Parts List, PPL-10, supplemented by specific tests based on the particular part and its principal failure modes.

3.6 PURCHASING AND STOCKING OF PARTS

3.6.1 PURCHASING OF PARTS

All electronic and electromechanical parts are purchased by Material Requests which are reviewed and coded by the Parts Laboratory prior to routing to purchasing. The Parts Laboratory assures that parts purchased for use in prime equipment are properly ordered and are contained on the ERTS Approved Parts List. In addition, this control point is used to provide assurance that other program requirements such as manufacturer's lot identification are reflected on the purchase order.

3.6.2 PACKAGING AND HANDLING

Upon completion of acceptance inspections and tests by the Parts Laboratory, each part acceptable for use in prime equipment is identified by a colored dot unique to the ERTS Program. Any part not bearing this identification will not be used for prime (qualification or

flight) hardware. Each part is individually contained in a package designed for the purpose of avoiding damage and/or degradation and maintaining identification. The lot code is clearly identified for each individually packaged part. The parts are then forwarded to a bonded stock area until they are required for assembly. The protective package is removed at the time of installation into the next higher assembly. At that time, the lot code number for each part is recorded and related to its unique location.

3.7 PARTS APPLICATION AND DERATING

In order to assure that each part is used within its capabilities, program application and derating factors have been established. These factors apply to all applications and assure that the use of parts is consistent with the ERTS goals and requirements. They form the basis of a realistic design approach and ensure that the usage is consistent with high reliability for the life of the mission.

3.7.1 APPLICATION AND DERATING FACTORS

Application and derating factors have been established consistent with a parts policy of burn-in at full load and application at reduced levels. This provides a high probability of failure-free operation during the mission. The derating factors are based on temperature to permit consideration of conditions such as duty cycle and method of mounting to be taken into account.

The primary responsibility for proper application of parts is the responsibility of the Design Engineer. The application and derating applied to each part is reviewed as part of the Reliability Analysis.

All electronic parts will be derated. Any part used at greater than 25 percent of its rating will be investigated to assure the applied part stress will not result in a potential problem. When the parts are operated in a hard vacuum (1×10^{-5} mm of Hg or lower pressure) the average case temperature of each individual part will not be higher than 50° C except for film resistors which may attain 70° C. Transistors, diodes, and integrated circuits will not exceed 100° C junction temperature. The part case temperature during the most severe portions of the flight mission profile will not exceed the average case temperature by more than 25° C.

Conditions are placed on the use of parts based on anticipated usage and to avoid possible problems during testing and flight. These conditions include both design tolerances and restriction on part usage.

1. Resistors. Circuit end-of-life tolerances are 2 percent for metal film (1 percent tolerance) and 10 percent for carbon composition (5 percent purchased tolerance).
2. Capacitors. Capacitors, except for tantalum, are derated to approximately 75 to 80 percent of rated dc voltage and solid tantalum capacitors to 67 percent or less of rated dc voltage. Solid tantalum capacitors are reviewed to assure that there is sufficient limiting impedance.

Restricted Types - The following capacitors types shall not be used without supporting justification and documented approval: Aluminum Electrolytic, Tantalum Wet Slug, Metalized Paper or Plastic Film Dielectric, and Paper or Film Types in molded cases.

3. Potentiometers. The use of potentiometers is permitted prior to qualification or acceptance testing, but must be replaced by fixed resistors for this testing and flight. Exceptions will require supporting justification and documented approval.

4. Connectors. The use of connectors is to be minimized in every possible way. Point-to-point wiring is to be used wherever applicable. Where connectors are used, patch cards should be used during testing to minimize the number of "connect-disconnect" actions.

5. Transformers and Inductive Devices. Transformers and inductive devices shall conform to MIL-T-27, grade 4 or 5, class R or higher, and life expectancy X or equal. Low-power pulse transformers shall conform to MIL-T-21038, grade 4 or 5, class R or higher and life expectancy X or equal. Magnet wire shall be type B2 per MIL-W-583 or equal, and shall be limited in size to awg No. 40 and larger. Radio frequency coils shall conform to grade 1, class B of MIL-C-15305.

3.8 SUBCONTRACTOR REQUIREMENTS AND CONTROLS

The programs and controls relative to parts, materials, and processes usage on the program include subcontractor activities, their sub-tier contractors, and all part suppliers. These requirements are reflected in the applicable work statements and component specifications. As a source of part and material selection, subcontractors have been supplied copies of the approved lists and application standards. Each subcontractor is required to submit his documented program plan to the contractor for approval. Subcontractor plans have been reviewed for conformance to program requirements. A record of all nonstandard parts approvals which have been granted to subcontractors will be maintained. In addition, a "where-used" list of electronic parts will be maintained for each item of subcontracted hardware.

3.9 ERTS APPROVED PARTS LIST 490L213

3.9.1 GENERAL

Approved Parts List 490L213 which supplements NASA GSFC PPL-10 has been prepared for the Earth Resources Technology Satellite Program. Parts appearing on this list have been selected using the following criteria:

1. NASA/GSFC PPL-10 (Sept. 69)
2. Parts used in existing design (Nimbus)
3. Parts required for use in new ERTS design.

Wherever possible, parts were selected from PPL-10. However, in some cases there is no part listed in PPL-10 which is technically suitable for a given application. A discussion of parts from 490L213 which are not listed in PPL-10 is provided herein.

As additional parts are identified for use during the design phase, they will be added to 490L213. Customer approval for parts not appearing on PPL-10 will be requested through the use of nonstandard part data sheets as required.

3.9.2 SELECTED PARTS

The parts listed in 490L213 but not in PPL-10 are shown below, along with the reasons for their selection:

1. Capacitors. All capacitors are listed in PPL-10.
2. Connectors. All connectors are listed in PPL-10.
3. Diodes. All diodes are listed in PPL-10.
4. Microcircuits. The National Semiconductor Co. LM101A operational amplifier has been selected because of its improved performance characteristics and short circuit immunity as compared to the MA709 listed in PPL-10.

   The Texas Instrument series 54L microcircuits have been selected to provide a coherent series of low power circuits which are compatible with design objectives. The particular circuits to be used have eutectic metal bonding and will be subjected to screening comparable to that required in PPL-10.
5. Relays. All relays are listed in PPL-10.
6. Resistors. All resistors are listed in PPL-10.
7. Transistors. Transistor 2N3227 is of the same basic construction from the same line as the approved TX 2N2369A, but selected for higher breakdown voltage and gain.
8. Wire and Cable. Raychem 44A wire and cable has been extensively used in previous GE space programs such as Nimbus and OAO and is chosen for its superior resistance to vacuum, radiation and cold flow.

3.9.3 APPROVED PARTS LIST 490L213

3.9.3.1 Scope

This list identifies parts approved for use in the Earth Resources Technology Satellite. Each device was selected as an optimum choice considering NASA GSFC List PPL-10, ERTS program requirements, experience, reliability, and availability. Derating factors, part application disciplines, and screening considerations are provided to enhance the probability of successful operation of the devices in the mission environment.

3.9.3.2 Applicability

This list is applicable for all parts intended for use in the Earth Resources Technology Satellite.

3.9.3.3 Applicable Documents

Applicable documents are specified in Tables 3.9.3-1 through 3.9.3-8.

3.9.3.4 Requirements

3.9.3.4.1 Device Approval

Devices listed herein are those common-use items evaluated and approved for conformance to ERTS program requirements, and the following selection considerations:

1. Devices have received prior approval on other space programs.
2. Favorable program history on the basic device.
3. Are optimized in terms of learning, cost and availability.
4. Optimum physics of construction for space flight applications.
5. Are qualified by test data on file.
6. Demonstration of vendor capability.

3.9.3.4.2 Derating and Application Factor Disciplines

Derating and application factors to enhance the probability of failure free operation in the mission environment are presented in Section 6. It is the responsibility of each design engineer to ensure that all parts are used in accordance with the design guidelines presented herein, and in every case are technically suited for the required application. In addition, such factors as function, environment, reliability, strength, safety, interchangeability, etc. shall be fully considered.

3.9.3.4.3 Screening

Screening of piece parts and microcircuits is required to be performed by the vendor or the purchaser. The purpose of screening is to remove those items which contain quality defects and which may suffer early catastrophic failure or parameter drift. The survivors of a lot of screened parts are expected to demonstrate the reliability and performance characteristics of which the design and process are capable. Unless otherwise specified in the detail drawing or other procurement document, screening shall be in accordance with GE standard 171A8329.

3.9.3.4.4 Sources

Parts shall be procured only from the sources indicated by the FSCM (Federal Supply Code for Manufacturers) on the drawing.

3.9.3.5 Approved Parts and Microcircuits

Approved parts are as listed in Tables 3.9.3-1 through 3.9.3-8.

3.9.3.6 Preparation for Delivery

Upon completion of all inspections and tests after receipt each part shall be contained in an individual package designed for the purpose of avoiding damage and/or degradation and maintaining identification. Serial numbers or lot code numbers shall comprise a part of the identification for each item. This number shall be marked on each container in addition to the identification number. The protective package shall be removed only when necessary to install the parts into the next higher assembly.

3.9.3.7 Derating and Application Factor Disciplines

Conservative design and manufacturing practices applicable to long-life, high-reliability spacecraft requirements will be used in all components. Every practicable means is to be employed to assure that no voltage or environmental stress in excess of those noted herein (or specified by the applicable component or subassembly specification) is applied to any portion of the prototype or flight components during processing, handling, assembly, testing or shipment.

1. Where no other application data is provided, all electronic parts are to be used at or below 25 percent of their power dissipation ratings. In any event the product design is to be such that under operating conditions in a hard vacuum (10^{-5} mm of Hg or lower pressure) the average case surface temperature of individual parts during flight will not be higher than:

Film resistors	70° C (158° F)
Composition resistors	50° C (122° F)
Relays	50° C (122° F)
Transformers	50° C (122° F)
Silicon Transistors	50° C (122° F) maximum junction temperature 100° C
Germanium Transistors	40° C (104° F) maximum junction temperature 60° C
Capacitors	50° C (122° F) see below
Diodes	Same as transistors
Connectors	50° C (122° F)

2. Circuit "end of life" tolerances for 3 year operation should provide for:

Film resistors of 1 percent purchase tolerance	±2%
Composition resistors of 5 percent purchase tolerance	±10%

3. Capacitors of all types, except tantalum, should be derated at least 50 percent of their dc voltage ratings. Tantalum foil units should be derated to approximately 75 to 80 percent of their dc voltage ratings. Solid tantalum capacitors should be derated to 67 percent, or less, of the voltage rating. The user is cautioned that solid tantalum capacitors have a higher failure rate when used in low impedance circuit applications (i.e., less than 3 ohms per applied volt) and the use of 16K type capacitors should be considered for those applications.

   Capacitors for ac applications and ripple applications should be derated to 80 percent of their ac rating and detailed thermal analysis should assure that in no instance can the case temperature exceed 70° C.

4. The contractor shall provide sufficient test instrumentation during the test of an engineering development model (or of other fully representative components or subassemblies) to determine the maximum case temperature of each of the more severe applications of each of the different part types used. This is to be done while the component is under operating conditions representative of space flight (e.g., in a hard vacuum of 1×10^{-5} mm of Hg or lower pressure).

5. Additional Sources of Application Data - Additional application data and ground rules for the application of parts and materials are presented in GE-SSO Standards Book I, Volume 1A, entitled "Application and Reliability Data." In some cases, individual application notes for special high usage parts are published in separate documents, for example, GE-SSO Standards 5905-27, 5916-63, and 5961-65. In many cases, application notes are contained in Section 6 of the part drawing, e.g., R4122.

3.10 SUMMARY

General Electric has a realistic, timely and economic Parts Program by applying proper emphasis to the following elements:

1. Use of parts with which we have experience and confidence
2. Sufficient testing to assure that only the most reliable parts find their way into spacecraft equipment:

   100 percent quality defect screening
   Acceptance Test
   QA Test at higher assembly levels

3. Assuring that parts are applied consistent with their capabilities and limitations (e.g., derating parts).
4. Assuring that subcontractors utilize similar techniques consistent with proprietary and shelf status.
5. Demonstrated effectiveness on past long-life missions, e.g., Nimbus, OAO, ATS, CCTS.

TABLE 3.9.3-1. CAPACITORS

Part Description	Type No.	Manufacturer		In-House Standard Specification No.	Notes
		Name	FSCM		
Capacitors, Fixed					
Glass	CYFR	Corning	16299	R9004, MIL-C-11272	
Mylar	CTM	GE	06001	R4122	
Ceramic	CKR	Vitramon	95275	MIL-C-39014, R11055	
Tantalum, Solid	CSR13	Sparague	56289	MIL-C-39003, R4024	
Tantalum, Foil	CLR25,27	GE	01002	MIL-C-39006, R11057	

TABLE 3.9.3-2. CONNECTORS

Part Description	Type No.	Manufacturer		In-House Standard Specification No.	Notes
		Name	FSCM		
Receptacle, Rectangular, Solder Contacts					
9 contacts	DEM-9S-NMB-1-A106	Cannon	71468	R4301	*
15 contacts	DAM-15S-NMB-1-A106				
25 contacts	DBM-25S-NMB-1-A106				
37 contacts	DCM-37S-NMB-1-A106				
50 contacts	DDM-50S-NMB-1-A106				
Plug, Rectangular, Solder Contacts					
9 contacts	DEM-9P-NMB-1-A106	Cannon	71468	R4301	*
15 contacts	DAM-15P-NMB-1-A106				
25 contacts	DBM-25P-NMB-2-A106				
37 contacts	DCM-37P-NMB-2-A106				
50 contacts	DDM-50P-NMB-2-A106				

*Drawing R4301 in preparation.

TABLE 3.9.3-3. DIODES

Part Description	Type No.	Manufacturer		In-House Standard Specification No.	Notes
		Name	FSCM		
Diodes, Silicon					
Switching	TX1N4148	CDC	07910	MIL-S-19500/116	
Reference	TX1N827	Dickson	12954	MIL-S-19500/159	
Regulator	TX1N746A thru TX1N759A	CDC	07910	MIL-S-19500/127	
Rectifier	TX1N4942	Unitrode	12969	MIL-S-19500/359	
Regulator	TX1N3016B thru TX1N3019B	Motorola Dickson	04713 12954	MIL-S-19500/115	

TABLE 3.9.3-4. MICROCIRCUITS

Part Description	Type No.	Manufacturer		In-House Standard Specification No.	Notes
		Name	FSCM		
Digital					
Quad 2-Input Gate (Type 54L00)	SN9965	T. I.	01295	R4093	
Dual 4-Input Gate (Type 54L20)	SN9966	T. I.	01295	R4095	
4 Bit Binary Counter (Type 54L93)	Note A	T. I.	01295	Note A	*
Dual S-K F/F (Type 54L73)	SN9972	T. I.	01295	R4094	
Hex Inverter (Type 54L04)	Note A	T. I.	01295	Note A	*
Analog					
Diff. Comparator	μA710	Fairchild	07263	R11068	
Operational Amplifier	LM101A	National	12040	R4187	

*GE Specification to be prepared for T. I. "SN9XXXX" series utilizing eutectic metal bonding.

TABLE 3.9.3-5. RELAYS

Part Description	Type No.	Manufacturer		In-House Standard Specification No.	Notes
		Name	FSCM		
DPDT, 2A General Purpose (Crystal Can)	Golden G	Deutsch	99699	R2053	
	3 SAF	GE	01526		
DPDT, 2A General Purpose (1/2 Crystal Can)	DJ	Deutsch	99699	R2340	
DPDT, 2A Magnetic Latching (Crystal Can)	3 SAM	GE	01526	R2313	
DPDT, 10A General Purpose	BR 19	Babcock	09026	R2047	
DPDT, 10A Magnetic Latching	BR 20	Babcock	09026	R2044	
DPDT, 2A General Purpose (Crystal Can)	SC	P & B	77342	-	*
DPDT, 2A Magnetic Latching (Crystal Can)	SL	P & B	77342	-	*

*Screen Parts to NASA/GSFC S-311-P2

TABLE 3.9.3-6. RESISTORS

Part Description	Type No.	Manufacturer		In-House Standard Specification No.	Notes
		Name	FSCM		
Resistors, Fixed					
Composition	RCR	Allen Bradley	01121	MIL-R-39008	
Film	RNR	MEPCO IRC	80031 07716	MIL-R-55182, R7111	
Wirewound, Power Type	RWR	Dale	91637	MIL-R-39007	
Wirewound, Power Type, Chassis Mount	RER	Dale	91637	MIL-R-39009, R4411, R4412	

TABLE 3.9.3-7. TRANSISTORS

Part Description	Type No.	Manufacturer		In-House Standard Specification No.	Notes
		Name	FSCM		
Silicon					
PNP, Gen. Purp.	TX2N2905A	National	12040	MIL-S-19500/290	
	TX2N2907A	National	12040	MIL-S-19500/291	
NPN, Gen. Purp.	TX2N2219A	Motorola	04713	MIL-S-19500/251	
	TX2N2222A	T. I.	01295	MIL-S-19500/255	
NPN, L. L. Amp.	TX2N930	T. I.	01295	MIL-S-19500/253	
PNP, Switch	TX2N3251A	T. I.	01295	MIL-S-19500/323	
NPN, Switch	TX2N2369A	Motorola	04713	MIL-S-19500/317	
		National	12040		
NPN, Switch	2N3227	Motorola	04713	-	*
N-Channel F. E. T.	2N5432	Siliconix	17856	-	*
NPN, Gen. Purp.	TX2N1613	Fairchild	07263	MIL-S-19500/181	**
		T. I.	01295		
NPN, Gen. Purp.	TX2N1711	Fairchild	07263	MIL-S-19500/225	**
		T. I.	01295		

*Specification to be prepared.
**TX2N2219A preferred for new design.

TABLE 3.9.3-8. WIRE AND CABLE

Part Description	Type No.	Manufacturer		In-House Standard Specification No.	Notes
		Name	FSCM		
Wire, Electrical, Insulated	44A/	Raychem	06090	R3980, MIL-W-81044	
Cable, Electrical, Twisted	44A/	Raychem	06090	R3701	

SECTION 4

MATERIALS AND PROCESSES

SECTION 4

MATERIALS AND PROCESSES

4.1 MATERIALS AND PROCESSES RELIABILITY PLAN

4.1.1 INTRODUCTION

The plan described herein for total materials and processes control provides the basis for effective and efficient action to assure compliance with the ERTS program requirements. The selection of materials and processes, the minimizing of material types used, the designation of adequate and appropriate specifications, the qualification of materials and processes, the maintenance of a current approved materials and processes list, the materials application review approach, and the acceptance testing of materials and processes are all implemented in accordance with the following requirements, policies, and procedures as appropriate:

NASA Reliability Publication NPC-250-1, Reliability Program Provisions for Space Systems Contractors.

4.1.2 GE-SS POLICIES AND INSTRUCTIONS AND STANDARDS

3.6 - Technical Standards

8.6 - Operators and Inspector Certification

8.12 - Parts, Materials & Processes Application Control

S30400 - General Specifications, Preparation Of

GE has effectively demonstrated its capability in selecting and testing materials to achieve long life in the space environment, e.g., the Nimbus Weather Satellites built by GE-SSO have significantly surpassed the long life goal of six months. The successful materials performance on the Nimbus and other SSO built satellites can be largely attributed to the effective material controls operating during the material and process selection, specification, and testing phases of these programs. These controls, as modified to meet the ERTS material requirements, form the basis for this materials control plan.

This materials control program has sufficient flexibility to allow for additional requirements and/or constraints demanded by the ERTS program objectives to be readily factored into the overall plan at any time. Materials control is initiated at the system design stage with the issuance of the approved materials list. All additions to this list are channeled through the materials applications function. Additional control is exercised through drawing sign off by the materials applications specialist. Control is further exercised through documentation and materials testing. Feedback through the functional organizations of status reports, test results, etc. highlight material problem areas for corrective action. As required by the NPC 250-1, the prime systems subcontractors and their suppliers are apprised of the provisions of the materials control plan and adherence to these requirements is made contractually binding.

To provide a high level of confidence that the material will perform successfully throughout the mission, the following selection criteria are used:

1. Performance history on other long life space program applications
2. Failure mechanism and mode studies indicating suitability of the material for long life space applications
3. Capability of a vendor to consistently produce material conforming to the specification requirements. This capability will be determined primarily by means of a review of past materials acceptance data and accumulated test and evaluation data
4. Material for which adequate historical data is not available will be thoroughly tested to determine suitability for the intended application

All material purchased for prime hardware usage is tested either at the vendor's plant and/or in-house. Material is ordered to complete controlled documentation. If there is no existing specification for a material or process, an applicable one is prepared. Material acceptance testing is performed in accordance with the test methods called for in the applicable specification. Shop operators and inspectors are trained and certified to perform or inspect specialized processes.

4.2 APPROVED MATERIALS AND PROCESSES LIST

The Approved Materials & Processes List (AMPL) (See Appendix A) is composed of individual listings of materials and processes identified by a general description, manufacturer's designation, the applicable specifications, approved sources, and general application information oriented toward design considerations.

Application limitations are indicated where necessary. The materials initially selected for inclusion in the ERTS AMPL 490L212 are those with a history of successful application on other long life space programs. The following are examples of additional approved lists that have been prepared for other programs:

Number	Title
490L100	Approved Material List - Unmanned Spacecraft Vehicles
490L102	Approved Material List - Program OAO
490L107	Approved Materials & Processes for ATS
490L115	Interchangeable Parts & Materials - Program GGTS
490L122	NIMIT Approved Materials & Processes List
490L209	Selected Materials & Processes List - MM '71 ACS Subsystem

Number	Title
490L202	Approved Materials & Processes List - ATS F&G
490L485	Selected Processes List - 206 Programs
490L486	Selected Materials List - 206 Programs

4.2.1 APPROVED MATERIALS AND PROCESSES LIST MAINTENANCE

Whenever a request is made to add a new material or process, it must be adequately documented and justified before presentation to the materials specialists for analysis and approval. New materials and processes will be compared with similar approved types and reviewed for conformance with program qualification requirements for acceptability. Additional screening of qualifications will be performed through the use of recognized information systems. Supplementary bulletins to the AMPL will be issued frequently and distributed to all functions whenever several new materials and/or processes are added to the approved list. The approriate changes and/or additions to the AMPL will then be made to update it. All revisions will be processed through a formal design change board procedure.

Materials selected but not qualified will be classified as conditionally approved. Materials considered for a conditional approval must be potentially qualifiable based on engineering judgment and analysis in the absence of specific data and information.

Materials are assigned a limited approval when their application is a restricted classification. If a material does not meet all the requirements because the status of specifications, qualification data, or other documentation prohibits the preferred assignment, it will be classified for restricted use on ERTS designs when there are no immediate plans for additional evaluation and qualification.

The materials and processes data and information will flow to and from engineering, reliability, manufacturing, quality assurance operations, procurement, and other associated activities. All data and information will be coordinated and evaluated by the materials applications function, used to update the approved list, and to apprise all activities and functions concerned for action as appropriate.

4.3 MATERIAL AND PROCESS SPECIFICATION AND OTHER DOCUMENTATION

All materials and processes used on the ERTS program will be documented by specifications and standards (NASA, Military, Federal, Industrial, or GE). When it is established that there are no existing adequate specifications available, applicable specifications will be prepared. These documents will be prepared and maintained in accordance with the ERTS requirements. The latest concepts of document control, reliability, qualification, and conformance to measurable requirements will be incorporated into these documents. All specifications will contain storage, shelf life, packaging and marketing requirements where applicable, and will be available for review by the customer.

Specifications are reviewed by vendors for concurrence to achieve realistic requirements for materials and processes. Amendments and revisions are processed through a formal design change board procedure.

Process specifications will also be subject to review/negotiation by the vendor. These specifications establish the necessary processing requirements and quality assurance provisions to assure a reliable operation. Manufacturing standing instructions (MSI's) are internal process type documents of a proprietary nature. These documents contain more specific step-by-step detail than a general process specification. They are prepared and maintained by manufacturing engineering and coordinated with the materials engineering function. Standing instructions (SI's) are used to document proprietary formulations and special control and test procedures. MSI's and SI's involve only materials on the AMPL and which are covered by adequate specifications.

4.4 MATERIALS APPLICATION REVIEW AND MONITORING

Materials applications specialists supply materials information and consultation to Engineering from the initiation of the design efforts. Prior to design finalization, an applications review will be conducted to assure suitability of the material for the ERTS program application. This evaluation will be based on the following criteria:

1. Absence of adverse effects on the material from the environmental conditions associated with the application, or on the operating environment of other materials, e.g., outgassing
2. Material strength properties exceed the design loads by a sufficiently large safety factor
3. Sufficient performance and laboratory tear-down data available to justify the use of the material in its intended application
4. Freedom from inherent material weaknesses, such as excessive outgassing, radiation damage, etc. This assurance is acquired through engineering evaluation followed by failure mechanism and failure mode studies
5. The material must possess material interface capabilities with other materials with which it will come in contact. The potential problems of incompatibility resulting from fretting corrosion, electrochemical corrosion and direct chemical attack will be the subject of engineering evaluation and/or test programs, and preventative measures will be incorporated into the design
6. The selected material must have been approved for use on the ERTS spacecraft as indicated by inclusion in the AMPL

4.5 FAILURE REPORTING, ANALYSIS AND CORRECTIVE ACTION

Materials specialists participate in all failure analyses involving material and processing problems. The nature and cause of failure is determined by appropriate laboratory tear-down, examination, test, and environmental simulation techniques. Corrective action is implemented to prevent recurrence.

The materials failure analysis activity will include exploratory analyses in the design phase of the program to identify potential failure modes and the nature of construction of hardware. The results of these analyses will be coordinated with the customer, GE functions, and subcontractors.

4.6 MATERIALS ACCEPTANCE TESTING

All incoming raw, semi-finished, and fabricated materials are subjected to acceptance based on certification or in-house testing to determine compliance with the requirements of appropriate specifications. On completion of acceptance testing, reports are generated recommending dispositions for each lot of vendor supplied material and all in-process control tests performed. Problems related to specifications, test methods, limits, etc., that develop during this phase are reported to the materials engineering function for corrective action.

4.7 MATERIALS AND PROCESSES CONTROLS ON SUBCONTRACTORS

Subcontractor controls include reports and meetings between the GE materials engineering specialists and the subcontractor to review materials and process activities and resolve problems associated with the ERTS program. Vendor process certifications are performed as necessary to verify capability (equipment, personnel, process specifications, record keeping, etc.) to adequately perform specialized material processing. Process test specimens are evaluated as required by the applicable specifications.

4.8 SPECIALIZED MATERIALS PROCESSING

Shop operators and inspectors are trained and then certified after satisfactory completion of training to perform or inspect specialized processes. These include the processes designated in appropriate government and GE specifications as requiring certification. Examples are: adhesive bonding, potting or encapsulation, painting, surface treatments, soldering, fusion welding, cross wire resistance welding, and electron beam welding, heat treating, soldering etc. These activities involve a coordinated effort between the Manufacturing Reliability Training Center, manufacturing process engineering, and materials engineering specialists.

APPENDIX 4. A

APPROVED MATERIALS AND PROCESSES LIST

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED

APPROVED MATERIALS AND PROCESSES LIST

1.0 SCOPE

1.1 Purpose - The purpose of the document is to list the materials and processes approved for use on the ERTS Program.

1.2 Application - This list is intended for application on all ERTS Spacecraft designed by GE or their subcontractors.

1.3 The index is a listing of the contents of this document arranged alphabetically, showing the location of approved materials and processes by category and of other pertinent sections.

INDEX

2.0 APPLICABLE DOCUMENTS

2.1 Document Origin - This list includes specifications of the following origins: Department of Defense; General Services Administration; American Society for Testing and Materials; Society of Automotive Engineers; National Aeronautics and Space Administration; and the General Electric Company.

2.1.1 The current issue of each listed specification is applicable.

2.2 Document Preference - Where a choice of reference documents is offered, the preferred document is listed first and the less preferred documents are enclosed in parenthesis.

3.0 REQUIREMENTS

All materials and processes selected for use on the ERTS program shall be referenced to documents listed herein as applicable.

In the event that an indispensable material or process is not included in the current issue, this list may be changed only by Materials Performance Evaluation on request by the cognizant ERTS design engineer prior to reference on any engineering drawing or specification.

3.1 APPROVED METALLIC MATERIALS LIST

3.1.1 Aluminum and Aluminum Alloys

Material	Form	Specification	Issuing Agency	Description & Intended Use
Aluminum 1100	Foil, Sheet & Plate	QQ-A-250/1	Fed.	Commercially pure aluminum. Good formability, very good corrosion resistance, high thermal conductivity. Max. use temp. 300°F. Low mechanical properties.
	Bars, Rods, Wire	QQ-A-225/1 (B209)	Fed. ASTM	
	Tubing	WW-T-700/1	Fed.	
Aluminum 2014	Clad Sheet & Plate	QQ-A-250/3	Fed.	Heat treatable. High strength, high hardness, good formability. Sharp drop-in properties above 300°F. May be subject to intergranular corrosion.
	Forgings	171A8952 (146A9304) (QQ-A-367)	GE/S GE/S Fed.	
	Extrusions	QQ-A-200/2	Fed.	
	Sheet - "O" Cond.	AMS 4028	SAE	
	Plate & Sheet "T6" Cond.	AMS 4029	SAE	
Aluminum 2024	Sheet & Plate	QQ-A-250/4	Fed.	Heat treatable. High strength machinable and forging alloy widely used in aircraft structures. Sharp drop-in prop. above 300°F. May be subject to intergranular corrosion.
	Extrusions	QQ-A-200/3	Fed.	
	Tubing	WW-T-700/3	Fed.	
Aluminum 3003	Sandwich Cores	MIL-C-7438	DOD	Higher strength than 1100 aluminum. Non-heat treatable. Good formability, very good corrosion resistance, good weldability. Useful temp. between 200 & 300°F. Above 300°F prop. decrease rapidly.
	Tubing	WW-T-700/2	Fed.	
Aluminum 5052	Sheet & Plate	QQ-A-250/8	Fed.	Non-heat treatable. Good workability, high fatigue strength, weldability. Max. use temp. 300°F.
	Sandwich Core	MIL-C-7438	DOD	
	Tubing	WW-T-700/4	Fed.	

3.1.1 Aluminum and Aluminum Alloys (Cont.)

Material	Form	Specification	Issuing Agency	Description & Intended Use
Aluminum 6061	Sheet & Plate	QQ-A-250/11	Fed.	Heat treatable. Medium strength, good formability, weldability, and very good corrosion resistance. Max. use temp. 300°F.
	Extrusions	QQ-A-200/8	Fed.	
	Tubing	MIL-T-7081 (WW-T-700/6)	DOD Fed.	
Aluminum 7075	Sheet & Plate	QQ-A-250/12	Fed.	Heat treatable. Very good strength and fair corrosion resistance. Sharp property drop above 212°F. Poor weldability.
	Forgings	QQ-A-367	Fed.	
	Extrusions	QQ-A-200/11	Fed.	
Aluminum 356	Perm-Mold Castings	QQ-A-596 (ASTM B-108)	Fed. ASTM	Heat treatable casting alloy. Excellent castability, good weldability and pressure tightness, good resistance to corrosion.
	Sand Castings	QQ-A-601 (ASTM B-26)	Fed. ASTM	
Aluminum A356	Castings	MIL-A-21180	DOD	Heat treatable casting alloy. Higher silicon content than C355. Similar to 356, except lower impurity content gives higher mechanical properties.
Aluminum C355	Castings	MIL-A-21180	DOD	Heat treatable casting alloy. Good castability and pressure tightness. Corrosion resistance inferior to 356.

3.1.2 Copper and Copper Alloys

Material	Form	Specification	Issuing Agency	Description & Intended Use
Aluminum Bronze	Rod, Bar, Shapes, Forgings	QQ-B-679	Fed.	Comp. 1 (91 Cu-9 Al); Comp. 2 (81 Cu-10 Al-5 Ni). High strength, heat treatable alloys, corrosion resistant, good wear resistance. Rolled plates, forgings, & bars. Used for worm wheels, valve stems, shafts, etc.
Beryllium Copper #172	Strip, Bar Rod	QQ-C-533 (AMS 4530)	Fed. SAE	Heat treatable. Parts requiring excellent formability in the soft condition with high proportional limit, high fatigue strength, good hysteresis properties and creep resistance in hardened condition; corrosion resistant rel. high conductivity. Springs, diaphragms, bellows. Wear resistant and spark resistant.
	Wire	QQ-C-530 (AMS 4725)	Fed. SAE	
Brazing Alloy	Powder, Wire Rod, Sheet & Strip	QQ-B-650	Fed.	Copper, copper-zinc & copper-phosphorous alloys used for brazing ferrous & nonferrous alloys.
Electrolytic Copper	Sheet, Strip Plate	QQ-C-576	Fed.	99.95 copper. Conductors for all types of wires and cables, bus bars, switches and terminals
	Rods, Bars, Shapes	QQ-C-502	Fed.	"Tough Pitch" copper. Subject to embrittlement if heated in reducing atmosphere.
High Silicon Bronze	Rod, Bar, Sheet, Strip, Plate, Shapes	QQ-C-591	Fed.	Work hardenable, 96 Copper - 3 Silicon alloy. Hydraulic lines, fasteners, bearing plates, shafting, heat exchange tubes. Can be hot and cold worked. Can be joined by soldering or welding.

3.1.2 Copper and Copper Alloys (Cont.)

Material	Form	Specification	Issuing Agency	Description & Intended Use
Phosphor Bronze	Sheet, Strip Plate, Bar Shapes	QQ-B-750	Fed.	95 Copper - 5 Tin and Phosphorous, work hardenable. High strength alloy, used for springs, bellows, bearing plates, diaphragms, fasteners and switch parts. Material tends to become friable at elevated working temperatures.
	Wire	QQ-W-401	Fed.	
	Tubes, Seamless	MIL-T-3595	DOD	
Solid, Tinned Copper	Wire	R2311 (QQ-W-343)	GE/R Fed.	Electrical wire. Uninsulated. Pure tin exposed to subzero ^{o}F can be transformed to grey tin. If tin is electro-deposited, whiskers can grow on uninsulated wire.

3.1.3 Ferrous Alloys

Material	Form	Specification	Issuing Agency	Description & Intended Use
Steel AMS 6434	Plate, Sheet, Strip	AMS 6434	SAE	Low alloy heat treatable steel. For heat treated parts which require thorough hardening and tensile strengths above 180,000 psi. May be welded after heat treatment.
Steel 4130	Sheet	MIL-S-18729	DOD	Low alloy steel, hardenable. Weldable, medium strength alloy.
	Tubing	MIL-T-6736	DOD	
Steel 4140	Mech. Tubing	AMS 6381	SAE	Low alloy steel, hardenable. Not readily weldable, but similar to 4130 with greater depth of hardenability.
	Bars, Forgings	MIL-S-5626 (AMS 6382)	DOD SAE	
Steel 4340	Bars Forgings	MIL-S-5000 (AMS 6415)	DOD SAE	Deep hardening steel. Preferred low alloy steel for applications requiring good strength, high hardenability and uniformity. Usable to 750°F.
Steel 6150	Sheet, Strips Annealed	MIL-S-18731	DOD	Heat treatable. High fatigue strength, high mechanical strength, use at hardness of Rockwell C44-49. Suitable for larger size music wire.
	Wire	AMS 7301	SAE	
Steel 8750	Bar, Forgings Tube, Billet	AMS 6328	SAE	Low alloy steel with through hardening capability in small sections. Medium and heavy duty carbonized gears, etc., heavy duty bolts. Usually supplied as bar, forgings, tubing, or billet.
Steel 52100	Bars, Forgings Mech. Tubing Wire	AMS 6444	SAE	Chromium (1) Carbon (1) hardenable alloy steel. Hardenable steel which develops high strength and wear resistance and good fatigue resistance. Bearing applications.

3.1.3 Ferrous Alloys (Cont.)

Material	Form	Specification	Issuing Agency	Description & Intended Use
Steel 1090	Wire	QQ-W-470 (AMS 5112)	Fed. SAE	Cold worked wire. High strength material for small springs, mechanical springs with wire size less than 0.028". Use below 250°F and above 0°F.
Stainless 17-4 PH	Bar, Forgings	AMS 5643	SAE	Age hardening stainless steel. High strength-weight ratio, good corrosion resistance. Readily welded. Max. use temp. 600°F.
Stainless 17-7 PH	Sheet, Plate Strip	MIL-S-25043 (AMS 5528)	DOD SAE	Age hardening nearly austenitic. High strength to 240,000 psi tensile. Better than 302 or 304 corrosion resistance. Easily welded and formed. Can be used up to 900°F.
	Bar, Forgings	AMS 5644	SAE	
Stainless 17-7 PH	Wire	MIL-W-46078 (AMS 5673)	DOD SAE	Cold worked, heat treated wire. Combines high mechanical properties wire with corrosion resistance of life springs operating under severe conditions.
Stainless 301	Plate, Sheet & Strip	QQ-S-766	Fed.	Work hardenable to high strength levels. Corrosion resistant. High strength applications. Use below 750°F.
Stainless 302	Sheet	QQ-S-766	Fed.	Austenitic steel. High strength when cold worked, excellent corrosive resistance, weldable. Does not require post weld treatment.
	Bar	QQ-S-763	Fed.	
Stainless 303	Bars, Shapes Forgings	QQ-S-763 (MIL-S-7720)	Fed. DOD	Free machining stainless. Austenitic, stainless steel; excellent machining characteristics; good corrosion resistance. Plating adheres poorly. Good for bolts, screws, etc.

3.1.3 Ferrous Alloys (Cont.)

Material	Form	Specification	Issuing Agency	Description & Intended Use
Stainless 304	Sheet	QQ-S-766	Fed.	Austenitic steel. Excellent weldability in 304L compositions. Excellent atmospheric resistance. Use below 700°F. Not heat treatable. Some suitability at cryogenic temperatures.
	Tubing	MIL-T-8506	DOD	
	Bar	QQ-S-763	Fed.	
Stainless 321	Bars, Shapes & Forgings	QQ-S-763	Fed.	Cold worked. Generally used for high temperature (800-1600°F). Corrosive conditions and where post-weld annealing not practical.
	Plate, Sheet & Strip	QQ-S-766	Fed.	
Stainless 347	Tubing	MIL-T-8606	DOD	Austenitic steel. Useful for parts welded without post weld annealing or for long service between 800-1500°F. Good cryogenic temperature properties. Corrosion resistant.
	Sheet	QQ-S-766	Fed.	
Stainless 410	Castings	MIL-S-16993	DOD	Martensitic steel, hardenable. Corrosion resistance and moderate strength to 1000°F. Not suitable for cryogenic service.
	Plate, Sheet & Strip	QQ-S-766	Fed.	
Stainless 431	Bar	QQ-S-763 (MIL-S-18732)	Fed. DOD	Martensitic steel magnetic, heat treatable. A marginally heat treatable moderate strength steel useful to 900°F. Superior corrosion resistance to other 400 series steels. Excellent impact strength.
Stainless 440 C	Bars, Forgings	QQ-S-763	Fed.	Chromium (18) Carbon (1) hardenable stainless steel. Hardenable stainless steel which develops max. hardness, corrosion resistance, strength and wear resistance. Bearings shafts, gears. Very low impact strength.

3.1.4 Magnesium and Magnesium Alloys

Material	Form	Specification	Issuing Agency	Description & Intended Use
AZ31B	Sheet & Plate	QQ-M-44 (ASTM-B-90)	Fed. ASTM	Low cost wrought alloy. Moderate mechanical properties & high elongation. Good formability & strength, high corrosion resistance, good weldability. Seldom forged. Max. use temp. 300°F. Heat treatment limited to stress relief annealing.
	Extrusions	QQ-M-31	Fed.	
	Tubing	WW-T-82	Fed.	
AZ61A	Forgings	QQ-M-40 (ASTM-B-91)	Fed. ASTM	General purpose extrusions, press forgings with good mechanical properties. Max. service temp. 300°F. Heat treatment limited to stress relief annealing.
	Extrusions	QQ-M-31	Fed.	
	Tubing	WW-T-825	Fed.	
AZ91C	Castings	118A1629 (QQ-M-56) (ASTM-B-80)	GE/M Fed. ASTM	Pressure-tight sand and permanent mold castings with high tensile and yield strength. Max. use temp. 300°F. Heat treatable.
HK31A	Sheet & Plate	MIL-M-26075 (ASTM-B-90)	DOD ASTM	High strength at elevated temp. Heat treatable. Sheet and plate with excellent weldability and formability. High strength value at 600°F. Sand casting alloy for elevated temp. use.
	Castings	118A1629 (ASTM-B-80) (QQ-M-56)	GE/M ASTM Fed.	
LA 141A (Mg-Li)	Sheet & Plate	AMS 4386	SAE	Light weight, low strength alloy where low density is prime criterion. Max. use temp. 200°F. (Tensile strength decreases from 26K psi to 13K psi.)
M1 A	Extrusions	QQ-M-31	Fed.	Non-heat treatable, yield strength increased by cold work. As wrought products with moderate mechanical properties, excellent weldability, corrosion resistance & hot formability. Max. use temp. 200°F.
	Forgings	QQ-M-40	Fed.	
	Tubing	WW-T-825	Fed.	

3.1.4 Magnesium and Magnesium Alloys (Cont.)

Material	Form	Specification	Issuing Agency	Description & Intended Use
ZE41A	Sand Castings	118A1629 (ASTM-B-80)	GE/M ASTM	Good castability. Heat treatable. Pressure tight applications, weldability. Max. use temp. 200°F.
ZH62A - T5	Sand Castings	147A1882 (QQ-M-56)	GE/S Fed.	High strength sand cast structural alloy. Very high yield strength.
ZK60A	Extrusions	QQ-M-31	Fed.	Heat treatable. High strength wrought alloy with good ductility. Low notch sensitivity. Max. use to 200°F.
	Forgings	QQ-M-40 (ASTM-B-91)	Fed. ASTM	
	Tubing	WW-T-825	Fed.	

3.1.5 Magnetic Materials

Material	Form	Specification	Issuing Agency	Description & Intended Use
Alloy 4750	Sheet, Strip, Bars, Forgings Rod, Tubing	AMS 7717 AMS 7718	SAE SAE	Nickel (47-50%) Iron alloy. Good overall magnetic characteristics, high permeability and low loss, used in audio transformers, coils, relays. Magnetically soft material.
Alnico 2	Cast Sintered	QQ-M-60, CL.B2 QQ-M-60, CL.B5	Fed. Fed.	Aluminum (10) - Nickel (17) - Cobalt (12.5) - Copper (6) - Iron alloy. Permanent magnet applications where lower cost sintered or cast Alnico having lesser magnetic properties may be used. Size limitation less severe than Cunife.
Alnico 5	Cast Sintered Cast (Varying Magnetic Props)	QQ-M-60, CL.B4 QQ-M-60, CL.B9 147A1868	Fed. Fed. GE/S	Aluminum (8) - Nickel (14) - Cobalt (24) - Copper (3) - Iron alloy. Permanent magnet applications where max. energy per volume is required.
Cunife	Wrought Bars, Rods, Strips & Wire	QQ-M-60, CL.C2	Fed.	Copper (60) - Nickel (20) - Iron (20) alloy. Permanent magnetic application where wrought products are required for forming and fabrication. Size limitations for maximum magnetic properties.
Mumetal	Sheet, Strip Sheet 1/2 Hard Bars, Forgings	AMS 7701 AMS 7702 AMS 7705	SAE SAE SAE	Nickel (77) - Copper (5) - Chrome (1.5) - Iron alloy. Very high permeability, low losses, audio coils, transformers, magnetic shields.
Silicon Steel (M-19)	Sheet, Strip	AMS 7714	SAE	3% Si Steel. Good ductility, intermediate magnetic qualities, magnetically soft material for stators of rotating equipment, transformer cores.

3.1.6 Special Purpose Alloys

Material	Form	Specification	Issuing Agency	Description & Intended Use
Invar 36	Bar	MIL-S-16598	DOD	Ni (36) - Iron alloy. Low thermal expansion alloy, temp. compensators, thermostats, seals. Useful to 350°F.
Invar 49	Strip, Bar Rod	MIL-N-22840	DOD	Nickel (47-50) - Iron alloy. Low thermal expansion alloy, temp. compensators, thermostats, seals. Useful to 850°F.
Kovar	Part leads	S30203	GE/S	Nickel (29%) - Cobalt (17%) - Iron (Bal). Low thermal expansion alloy for larger temp. ranges, temp. compensators. Use for sealing to hard glasses.
	Bar, Forgings	AMS 7727	SAE	
	Wire, Rod	171A8211 (AMS 7726)	GE/S SAE	
	Sheet, Strip	AMS 7728	SAE	
Nichrome V	Wire, Welding	MIL-R-5031, CL.7 (AMS 5676)	DOD SAE	80 Ni - 20 CR. An electrical resistance alloy with high temp. coefficient of resistivity. Useful for welding high Ni alloys.

3.1.7 Titanium and Titanium Alloys (See Note 1)

Material	Form	Specification	Issuing Agency	Description & Intended Use
4 Al, 4 Mn (C130 AM)	Forgings, Rod, Bar	MIL-T-9047, CL.6 (AMS 4925)	DOD SAE	Heat treatable alpha-beta alloy. Usually used as bar, forgings and fasteners for aircraft applications. Not recommended for welding. Useful to 750°F. (See Note 2)
5 Al - 2.5 Sn (A110AT)	Sheet, Plate Strip	MIL-T-9046, TY2 Comp. A (AMS 4910)	DOD SAE	Non-heat treatable. Alpha alloy. Good strength to 800°F with excellent weldability. Limited formability. Good cryogenic properties. (See Note 2.)
6 Al, 4 V (C120AV)	Sheet, Plate, Strip	MIL-T-9046, TY3 Comp. C (AMS 4911)	DOD SAE	Heat treatable alpha-beta alloy. Intermediate strength levels and stability to 750°F. Good cryogenic temps. Fair weldability. Notch time rupture sensitivity very low to nil. (See Note 2.)
	Forgings, Rod	MIL-T-9047 CL.5 (AMS 4928)	DOD SAE	
	Wire, Welding	AMS 4954	SAE	
	Extrusion	AMS 4935	SAE	
8 Mn (C110M)	Sheet, Plate Strip	MIL-T-9046, TY3 Comp. A (AMS 4908)	DOD SAE	Alpha-beta alloy (non-heat treatable). Good elevated temp. strength and stability to 600°F. Good formability, limited weldability. Cryogenic properties good. (See Note 2.)
99Ti	Sheet, Plate, Strip	MIL-T-9046, TY1	DOD	Unalloyed titanium. Good fabricability, intermediate strength, high corrosion resistance, good weldability. Useful to about 400°F. Good at cryogenic temp. (See Note 2.)
	Forgings	MIL-T-9047, CL.1	DOD	
	Tubing, Welded	AMS 4941	SAE	

Notes: 1. Above 600°F, NaCl can cause stress corrosion of titanium alloys.
2. Not to be used with oxidizing media.

3.1.8 Other Metallic Materials

Material	Form	Specification	Issuing Agency	Description & Intended Use
Gold	Electroplate	MIL-G-45204	DOD	Plated film. Lubricating coating for bearings, gears, contacts, optical surfaces. Corrosion resistant surface.
Molybdenum	Sheet, Strip	MIL-M-27524	DOD	Refractory non-magnetic. Low thermal coefficient of expansion, high electrical cond. high tensile strength.
	Rod, Wire	MIL-M-14582	DOD	
Nickel	Flat Wire	S30200	GE/M	Annealed nickel ribbon. Tensile strength (PSI) 60,000 min., 75,000 max. Module interconnections.
Solder Al Alloy	Wire	MIL-S-12204	DOD	Sn-Zn-Al, or Sn-Zn alloy used in joining aluminum and its alloys.
Solder 60-40	Bar, Wire	QQ-S-571 Comp. SN-60	Fed.	Solder alloy, 60 Tin. Electronic joining.

3.2 APPROVED NON-METALLIC MATERIALS LIST

3.2.1 Adhesives

Material	Form	Specification	Issuing Agency	Description & Intended Use
Eastman 910	Liquid	171A8200 (128A5480)	GE/S GE/R	General purpose, fast setting. Used where instantaneous bonding is desired or with surfaces which are irregular or acidic in nature and primarily as a processing aid. Bond strength sensitive to humidity.
Eccobond 60L	Paste	147A1286	GE/R	Thermally conductive epoxy adhesive. Carbon filled. Gives strong, rigid bond. Useful temperature range: -60 to 250°F.
Epibond 123	Liquid	171A4235 (147A1809)	GE/S GE/R	Unfilled epoxy, general purpose adhesive.
Epon 815, 820, 828	Liquid	171A4424 (171A8212) (128A5454)	GE/S GE/S GE/R	Unfilled epoxy resin adhesives. Very strong adhesive bond. Used as structural adhesive. Useful temp. range: -60 to 250°F.
HT-424	Paste Foam Film Adhesive	156A9700 147A1270 MIL-A-5090	GE/R GE/R DOD	Phenolic epoxy. Glass cloth supported film adhesive used in honeycomb fabrication. Useful temp. range: -400 to +500°F.
PD 454, 458, 459	4-Component Liquid	147A1856	GE/S	Clear adhesive, epoxy modified. A high light transmission adhesive for bonding cover glasses to solar cells. It is resistant to radiation darkening and thermal cycling.
Pliobond 20, 30	Liquid	171A8281 (128A5466)	GE/S GE/R	Thermal plastic adhesives, can be brushed or sprayed. Adversely affected by high temp. and maintained stress.

3.2.1 Adhesives (Cont.)

Material	Form	Specification	Issuing Agency	Description & Intended Use
Resiweld 7004	Liquid	171A4515 (171A4328)	GE/S GE/S	Epoxy adhesive for rigid or flexible bonding.
SS4004 Silicone Primer	Liquid	171A4414 (171A8243) (128A5489)	GE/S GE/S GE/R	Silicone primer for adhesive bonding.
TETA	Liquid	171A8203 (128A5459)	GE/S GE/R	Triethylene tetramine. Hardener for Epon resins 815, 820, 828.
92-009	Liquid	171A4501	GE/S	One part silicone rubber based adhesive used to bond silicone materials to metals and laminates.
RTV 566 A/B	Liquid	171A4575	GE/S	Two part room temperature vulcanizing silicone rubber compound. For use in temp. range of -175°F to +600°F where low outgassing is required.

3.2.2 Ceramics and Glass

Material	Form	Specification	Issuing Agency	Description and Intended Use
Alumina	Shapes	171A4423, TY2	GE/S	Solid bodies, 97% aluminum oxide. High temperature applications, circuit boards
Alumina	Powder	147A1244	GE/S	Powder aluminum oxide. Filler for the formulation of encapsulants.
Berlox	Shapes	171A4423 TY4	GE/S	Sintered beryllium oxide. Electronic grade. A material of extremely high thermal conductivity (greater than aluminum at room temperature) with high electrical resistivity used as thermally conductive electrical insulators for transistors. Hazardous do not saw, grind, make dust, etc.
Beryllia	Shapes	171A4423 TY4	GE/S	Solid bodies, refractory grade beryllium oxide. Circuit board material. See Berlox, above.
Fiberglass	Thread	147A1879	GE/S	Used where a sewing thread is required which possesses high tensile strength and resistance to high temperature.
Forsterite F20	Various Shapes	147A1271	GE/R	Sintered magnesia-silica. High temperature resistant ceramic used as an electrical insulator.
Fused Silica (7904M)	Multi	147A1236	GE/R	Fused silica, clear. Optical windows solar cell covers, insulation.

3.2.3 Coatings and Finishes

Material	Form	Specification	Issuing Agency	Description and Intended Use	Supplier
Acryloid	Liquid	171A4230	GE/S	Dries rapidly, becomes relatively hard. Used as a lacquer and a vehicle for pigments.	Rohm & Haas Co.
Optical Velvet Black Paint	Liquid	171A4173	GE/S	Acrylic-based black paint $\alpha_s = .98 + .01 - .04$ $\Sigma_n = .96 \pm .2$ Excellent all-around flat black paint. Space simulator internal surface coating-other companies using on space-craft surfaces. Should be vacuum baked where outgassing is critical.	3M
Pyromark Grey Paint	Liquid	171A8250	GE/S	White: titanium dioxide pigmented silicone-base paint. $\alpha_s = .022 \pm .04$ $\Sigma_n = .088 - .05$ Black: $\alpha_s = .92$, $\Sigma_n = .87$. Good thermal radiative property stability in space environment, however, white paint shows low stability. Must be baked at elevated temperature to decrease outgassing when used in line-of-sight of optics.	Tempil Corp.

3.2.3 Coatings and Finishes (Cont'd)

Material	Form	Specification	Issuing Agency	Description and Intended Use	Supplier
Wash Primer	Liquid	171A4444 (156A8980) (MIL-P-15328)	GE/S GE/R DOD	Penetrant primer Formula #117. Used as a pre-treatment primer to enhance adhesion of overcoats.	M.A. Bruder, Sherwin-Williams
SMRD 100	Liquid	171A4245	GE/S	Clear, flexible, epoxy compound, heat sterili sterilizable. Used as protective coating.	GE/SD
Zinc Chromate Primer	Liquid	MIL-P-8585	DOD	Low moisture sensitivity, corrosion inhibiting primer. Used for corrosion protection on aluminum and magnesium alloys pre-treatment and primers.	M. A. Bruder, Sherwin-Williams
#47865 Black Paint	Liquid	171A4449	GE/S	High emittance black paint (should not be used in direct line of sight to optics unless coating has an additional vacuum bake cycle).	Lowe Bros.

3.2.4 Encapsulants, Conformal Coatings and Related Materials

Material	Form	Specification	Issuing Agency	Description and Intended Use	Supplier
A4004 A4094	Liquid	171A4414 (171A8243) (128A5489)	GE/S GE/S	Primers for silicone adhesives	Dow-Corning
MPC 52	Liquid	171A8299 (147A1829)	GE/S GE/R	Two component, filled epoxy encapsulant having medium density and high thermal conductivity. Standard cordwood module encapsulant sets up hard, rigid solid. Glass and ceramic-jacketed parts should be provided with a barrier coating prior to encap. to avoid breakage. Non-repairable. Useful temp. range: -50 to +250°F.	GE/S
PR 1531	Liquid	147A1888, Type 4	GE/SD	Primer used with PR 1538. Used to enhance adhesion of 1538 to metallic and non-metallic surfaces.	Product Research Inc.
PR 1538	Liquid	171A4420	GE/SD	Clear or black flexible urethane compound. Encapsulant and conformal coating. Used to pot harness connectors and conformally coat circuit boards. Does not damage glass and ceramic jacketed electronic parts. Useful temp. range: -90° to +300°F. Repairable.	Product Research Inc.

3.2.4 Encapsulants, Conformal Coatings and Related Materials (Cont'd)

Material	Form	Specification	Issuing Agency	Description and Intended Use	Supplier
Quadrol Tetrol	Liquid	171A4194 (147A1257)	GE/S GE/R	Catalyst - polyol-amine type for polyurethanes.	Wyandotte Chem. Corp.
SMRD 49	Liquid	171A4242	GE/S	Two component, room temperature curing epoxy. Used where lightweight and low viscosity are prime considerations. Standard cordwood module encapsulant. Cures to a hard, rigid solid. Glass and ceramic-jacketed parts should be provided with a barrier coating prior to encapsulation to avoid breakage; non repairable; useful temperature range: -50° to +250°F.	GE/S
SS4004 SS4056	Liquid	171A4414 (171A8243) (128A5489)	GE/S GE/S GE/R	Primers for silicone adhesives.	GE Silicone Products

3.2.5 Insulating Materials

Material	Form	Specification	Issuing Agency	Description and Intended Use	Supplier
EM-FAB TV20-60	Fabric	147A1817 (171A8247	GE/S GE/S	Teflon impregnated 108 style glass fabric. External white fabric covering for insulation blanket assemblies.	Pallfex Products Corp.
Epoxy Glass	Sheet	147A1222 (S30205 P2) (MIL-P-18177)	GE/R GE/M DOD	Rigid epoxy glass. Circuit boards.	GE
Flexible Sleeving	Tube	MIL-I-1857A	DOD	Silicone resin coated braided fiberglas sleeving. Insulation sleeving for electronic part lead-wires. Excellent heat resistance and flexibility, push back, resilience, and resistance to penetration. Rated for 200°C operation and belongs in NEMA Type 5.	
Mylar	Film	MIL-P-43018	DOD	Plastic film "Cronaflex". A high strength film having good electrical properties and moisture resistance. Service temperature -60 to 300°F. Maximum radiation -10^{-7} erg/gram. Where dimensional stability is required, should be preshrunk for several hours at a temperature in excess of maximum operating temperature. Material becomes brittle after 3 months exposure to UV light ($2\text{-}4 \times 10^{3}$ Å). When used in drive belt applications, the material tends to crystallize and fracture after several thousand hours operation at ambient conditions.	E. I. duPont de Nemours Co., Inc.

3.2.5 Insulating Materials (Cont'd)

Material	Form	Specification	Issuing Agency	Description and Intended Use	Supplier
Mylar, Aluminized	Coated Plastic	147A1819	GE/S	Aluminum coated plastic film. Insulation blankets. Material should be preshrunk at a temperature in excess of maximum operating temperature in an inert atmosphere to insure dimensional stability; shrinks preferentially along length. Embossed aluminized Mylar becomes brittle after 3 months exposure to UV light ($2\text{-}4 \times 10^{3}$ A).	Hastings Co., Hy-Sil Manuf. Company
Polyester Film Cronaflex CFM-7	Film	S30205 P1 (L-F-340)	GE/M Federal	Photosensitized, flexible Mylar-type film. Circuit boards.	E.I. duPont
Sealed-End Caps	Forms	171A4174	GE/S	Shrinkable sealed-end caps. Protection for ends of stripped wiring.	Raychem Co.
Silastic 820	Tube	171A4502	GE/S	Heat shrinkable, siliconesleeving.	Dow Corning
Sleeving, Polyvinylidene Fluoride (Kynar) Heat Shrinkable	Tube	R2551	GE/R	Irradiated, modified, polyvinylidene fluoride electrical insulating sleeving	Rayclad Tube Inc., Alpha Wire Corp.
Textolite 11555, 11617	Sheet	MIL-P-997,GSG	DOD	Silicone-glass laminates, type GSG, low thermal conductivity. Washers and bushings, panel boards requiring high temperature capability.	GE-LPD

3.2.5 Insulating Materials (Cont'd)

Material	Form	Specification	Issuing Agency	Description and Intended Use	Supplier
Textolite 11546	Tube Rod Sheet	147A1865 147A1812 MIL-P-18177, TY. GEE	GE/S GE/R DOD	Laminate, epoxy glass. A high insulation resistance continuous glass weave laminate having high humidity resistance. Maximum continuous operating temperature 260°F.	GE-LPD
Thermofit RNF 100	Tube	171A4209 (171A7578)	GE/SD GE/S	Polyolefin shrinkable sleeving. Terminal insulation	Raychem Corp.
Tissuglas Type 200A	Sheet	147A1818 (171A8248)	GE/S GE/S	Insulation, thermal. Porous, non-woven, glass fiber sheet sprayed with a cellulose derivative. Maximum service temperature, 1200°F.	AMF
1X-6004	Tube	171A4439	GE/S	Polyester, heat shrinkable	3M

3.2.6 Lubricants and Self-Lubricating Materials

Material	Form	Specification	Issuing Agency	Description and Intended Use	Supplier
CS-4144	Grease-Superclean	171A4224	GE/S	Chloro phenyl methyl silicone oil lithium octoate soap. For ball bearings - low to moderate loads, and needle bearings. Temperature range: -100° to 200°F in vac. Vacuum 10^{-5} torr. Closed gear-heads, low - high torques.	GE-SPD
DC55	Paste	MIL-G-4343	DOD	Silicone di-ester oil blend with grease used as lubricant between rubber and metal parts on pneumatic systems and low temperature applications.	Dow-Corning Corp.
Haynes 25 Stellite	Alloy	171A4427	GE/S	Haynes Stellite 25 balls and races and retainers. Useful from cryogenic to high temperatures. Vacuum 10^{-8} torr. High cost parts for special applications only.	Union Carbide
Molybdenum Disulfide (Moly Spray-Kote)	Dry Film	171A4165	GE/S	Freon solvent packaged in aerosol can. Used where extreme pressure conditions exist.	Dow Corning Corp.
MoS_2	Powder	MIL-L-7866	DOD	Micro size. Sliding surfaces. Rubbed or impinged.	Dow Corning Corp.

3.2.6 Lubricants and Self-Lubricating Materials (Cont'd)

Material	Form	Specification	Issuing Agency	Description and Intended Use	Supplier
MoS_2 71% H_2O Optional Graphite 7% Na_2O-SiO_2 22%	Paste or Spray	171A4228	GE/S	AML dry film. Bonded solid lubricant, machinable. Gears, support bushings, actuators, misc. sliding friction application. Misc. "one shot lubrication". Special preparation necessary.	Naval Air Engineering Center
Nylatron GS	Molded	S30202	GE/S	Nylon filled with molybdenum disulfide used for gaskets spacers, wear pads and bearings where low friction and low wear characteristics are desirable.	Polymer Corp. of Penna.
PTFE	Rod	MIL-P-19468	DOD	Teflon bushing. Bushings - low load. Support bearings - vacuum 10^{-7}.	
S-122 Fluoro-Carbon	Dry Film	47A101718	GE/R	Used as mold release or dry film lubricant. Supplied in aerosol can.	Miller-Stephenson Chem. Co.

3.2.7 Tapes

Material	Form	Specification	Issuing Agency	Description and Intended Use	Supplier
Co-Netic AA Alloy	Foil	171A4445	GE/S	Metal foil used for magnetic and electrostatic shielding of subsystem harnesses.	Perfection
Co-Netic AA Alloy	Tape	171A4202	GE/S	Metal foil tape with pressure sensitive adhesive. Magnetic harness shielding.	Perfection
EE-3990	Tape	171A4201	GE/S	Copper foil tape with pressure-sensitive adhesive. Electromagnetic harness shielding.	Permacel
EM-FAB TV 20-60	Tape	MIL-I-18746	DOD	Insulation tape, thermal. A polytetrafluoroethylene (Teflon) impreg. glass fiber for service as a thermal or electrical insulator up to 500°F.	
Flextite TGL	Tape	146A9597	GE/R	Self-fusing, electrical insulating silicone rubber tape.	F. Markel & Sons
GT-100, GT-300, GT-400	Tape	146A9027	GE/S	Polyester, heat sealable tape. Secure thermistor wires to insulation blankets.	Schjeldahl
Nylon Lacing	Tape	R2074	GE/M	Flat nylon lacing tape. White or black.	Gudebrod, Eon Corp., Hemingway & Bartlett

3.2.7 Tapes (Cont'd)

Material	Form	Specification	Issuing Agency	Description and Intended Use	Supplier
Nylon Tape Fasteners	Tape	147A1872	GE/S	Nylon tape fasteners; Velcro Hook & Pile; Insulation blanket edge edge fastener.	Velcro
T-18	Tape	171A8282	GE/S	Teflon tape .006" thick. Class H electrical insulating material. Useable over a temperature range of -100°F to 400°F (-70°C to 200°C).	Conn. Hard Rubber Co.
X-1170 X-1181	Tape	171A4438	GE/S	Electrically conductive. Pressure sensitive foil tape used for RF shielding.	3M
3M#56	Tape	MIL-I-15126	DOD	Polyester film with thermo-setting pressure sensitive adhesive. Harness bundle wrap.	3M
3M#850	Tape	147A1898 (156A9854)	GE/S GE/R	Metallized polyester film tape with pressure sensitive adhesive. Sealing and joining Mylar sheet assemblies.	3M

3.2.8 Other Chemical Materials

Material	Form	Specification	Issuing Agency	Description & Intended Use	Supplier
CAB-O-SIL M-5	Filler	128A5500	CE/R	Colloidal silica used in epoxies and polyesters as a thickening or gelling agent.	Cabot Corp.
Carbon Black Pigmented Anodize	Liquid	171A4227	GE/S	High emissivity coating.	GE/R
DEAPA	Liquid	147A1287	GE/R	Diethylamino propylamine used as a room temperature curing agent for epoxy resins. It is soluble in water and org. compounds.	Union Carbide Chemicals Company
Eccofoam FPH	Liquid	147A1261	GE/R	Polyurethane, foam-in-place systems.	Emerson Cummings
Epoxy, Shim	Liquid Paste	171A4172	GE/S	Fluid epoxy. Used to take up machining mismatch tolerance between critical separation flanges. Known compressive creep properties.	GE/S
Fluorosint TFE	Molded Shapes	171A4205	GE/S	Compression molded. Used as the quadraloop antenna dielectric material.	Polymer Corp.
G683	Grease	147A1855 (171A8231)	GE/S GE/S	Not a lubricant. Used as an interface filler for unbonded thermal joints, since material is radiation and vacuum compatible.	GE-SPD
HHPA	Solid	147A1203	GE/S	Hexahydrophthalic anhydride used as an epoxy hardener, imparts little or no color to the product.	National Aniline Div., Allied Chemical Corp.

3.2.8 Other Chemical Materials (Cont.)

Material	Form	Specification	Issuing Agency	Description & Intended Use	Supplier
Insulation Sleeving	Tube	128A5289	GE/R	Teflon sleeving. Transparent	Pa. Fluoro-carbon Co.
Lexan Series, Lexan 101-701	Molded, Extruded	AMS 3628 (A16B28)	SAE GE/ES	Polycarbonate polymer thermo-plastic. Rigid, exceedingly tough material with excellent dimensional stability. Transparent.	GE-CMD
	Sheet	A16B54	GE/ES	Useful temp. range: -300° to +295°F. Gears, molded covers. Subject to solvent crazing.	
Loctite	Liquid	171A8291 (MIL-S-22473) (128A5483)	GE/S DOD GE/R	Sealant. Single component polyester type resin. Different grades give wide range of strengths, viscosities and degrees of adhesion for various lockings, retaining and sealing applications. Grades C & E not recommended for use above 110°F due to outgassing of condensables.	Loctite
Marking Ink, M-O-N Series	Liquid	171A4505	GE/S	Epoxy base permanent marking ink used on electronic equipment.	Warnow
MSD-104	Grease	171A4157	GE/S	Silver powder-filled CS4073 A = 5%, B = 60% nominal Ag content. Thermally & electrically conductive joint filler.	GE/SD

3.2.8 Other Chemical Materials (Cont.)

Material	Form	Specification	Issuing Agency	Description & Intended Use	Supplier
Nylon	Film, Sheet, Fiber, Molded	MIL-N-18352	DOD	Polyamide thermo-plastic polymers. Multi-use polymers which are stiff, strong, tough resistant to chemical attack & possess low coefficient of friction. Max. service temp. 250°F continuously. Max. radiation resistance 10^9 rads. Appx. 2.5% wt. loss of water in vacuum.	Various
Octoil-S Octoil Butyl Phthalate	Fluid	171A4163	GE/S	Ester type vapor pump fluids suitable for use as damping fluids.	Consolidated Vacuum Corp.
Polyimide Vespel SP-1 & SP-2	Film Molded	171A4232	GE/S	Thermoplastic polymer of superior temperature resistance to 700°F. Excellent high temp. electrical & mechanical properties. Electrical insulation at high temp. Journal bushings & gear applications. Molded parts are brittle & availability is limited.	duPont
Silicone Damping Fluid	Liquid	171A4506	GE/S	A chemically inert silicone fluid used as a hydraulic medium or as a damping fluid.	Dow Corning
Silicone Rubber SE 555, 751, 5601	Molded, Extruded	128A5469	GE/R	Molded silicone rubber. Useful temp. range: -75° to +450°F. Low compression set. Used for gaskets, "O"-rings & seals. Oil resistant.	Various Fabricators

3.2.8 Other Chemical Materials (Cont.)

Material	Form	Specification	Issuing Agency	Description & Intended Use	Supplier
Teflon	Film	MIL-P-22241 (AMS 3652)	DOD SAE	Tetrafluoroethylene polymer thermoplastic. Low coefficient of friction, excellent electrical & chemical properties. Useful temp. range: -450°F to +500°F. Max. radiation resistance: 10^6 -10^7 rads. Subject to cold flow under stress, poor bondability.	duPont
	Rods, Molded, Extruded	MIL-P-19468	DOD		
	Molded, Parts, Rods, Tubes, Sheets	AMS 3651	SAE		
Tellite TD-3.55	Molded Shapes	171A4129	GE/S	Polyolefin loaded with titanium dioxide pigment of the rutile type. Used as dielectric material.	Tellite
Viton A Rubber	Sheets, Molded Forms, "O"-Ring	MIL-R-25897 Type I & II, Class I	DOD	Fluorinated co-polymer rubber elastomer. "O"-rings, valve seats, seals, dampers, membranes. High damping capacity. Useful temp. range: -200° to +400°F.	duPont

3.3 APPROVED PROCESSES LIST

3.3.1 Cleaning

Process	Applicable Specification	Issuing Agency	Description and Intended Use
Cleaning Nitrogen System	171A4417 (118A1665)	GE/S GE/M	Requirements for cleaning nitrogen system parts and assemblies and cleaning requirements, pneumatic system components

3.3.2 Heat Treating*

Process	Applicable Specification	Issuing Agency	Description and Intended Use
Heat Treating Aluminum Alloys	MIL-H-6088	DOD	Requirements and procedures for heat treating.
Heat Treating Beryllium Alloys	MIL-H-7199	DOD	Requirements and procedures for heat treating.
Heat Treating Alloy Castings	MIL-M-6857	DOD	Requirements and procedures for heat treating.
Heat Treating Steel	MIL-H-6875	DOD	Requirements and procedures for heat treating.
Nitriding and Carburizing	MIL-S-6090	DOD	Surface hardening treatments.

*These specifications give procedures for surveying, and approving (certifying) the equipment and process controls.

3.3.3 Inspection

Process	Applicable Specification	Issuing Agency	Description and Intended Use
Certification of Penetrant Inspection and Magnetic Particle Inspection Personnel	MIL-STD-410	DOD	Requirements and tests for the certification of penetrant inspection and magnetic particle inspection personnel.
Penetrant Inspection and Magnetic Particle Inspection	MIL-I-6866	DOD	Fluorescent and nonfluorescent methods for detecting surface flaws. Procedure for detection of surface and subsurface flaws in magnetic materials.
Radiographic Inspection	MIL-STD-453	DOD	Procedural and personnel requirements for the radiographic inspection of material for the presence of internal defects.
Radiographic Inspection	MIL-R-11468	DOD	Soundness requirements for arc and gas welds in steel.
Ultrasonic Inspection	118A1582	GE/M	Aluminum, magnesium, steel, and titanium forged parts.

3.3.4 Metal Joining

Process	Applicable Specification	Issuing Agency	Description and Intended Use
Aluminum Dip Brazing	147A1845	GE/R	Aluminum and aluminum alloys. Flux bath brazing.
Brazing	MIL-B-7883	DOD	Steels, copper, copper alloys and nickel alloy. Brazing by all methods.
Flash Welding	MIL-W-6873	DOD	Carbon and alloy steel.
Gas and Inert Arc Welding	MIL-W-8604	DOD	Aluminum alloys.
Gas and Inert Arc Welding	MIL-W-18326	DOD	Magnesium alloys.
Gas Welding lA	MIL-W-8611	DOD	Carbon and alloy steel.
Metal Arc Welding	MIL-W-8611	DOD	Carbon and alloy steel. Corrosion and heat resistant alloys.
Operator Qualification Electrode Inert Arc Welding	MIL-T-5021	DOD	Qualification for welding carbon and stainless steel, Cu, Ni, Al, Mg, and Ti alloys.
Riveting	MIL-STD-403	DOD	Aluminum, solid rivets, non-flush and counter sunk.
Riveting	171A4287 (118A1507) (118A1508)	GE/S GE/M GE/M	Requirements for riveting - using solid and blind rivets.
Riveting	118A1506	GE/M	Requirements for riveting - using hi-shear and blind rivets.
Soldering	MIL-S-6872	DOD	General procedure for soldering with tin-lead and lead-silver solder.
Soldering	NHB 5300-4 [3A]	NASA	High reliability electronic soldering - highest standard.

3.3.4 Metal Joining (Cont'd)

Process	Applicable Specification	Issuing Agency	Description and Intended Use
Soldering	S30011	GE/M	Standard covering acceptance criteria for soldered joints.
Soldering	S30027	GE/M	Standard covering requirements for soldered connectors.
Spot and Seam Welding	MIL-W-6858	DOD	Aluminum and magnesium alloys, steel, nickel and heat resistant alloys, titanium alloys.
Weldments	146A9614	GE/M	Establishes standards for acceptance of fusion weldments in corrosion and heat resistant alloys, aluminum and magnesium, carbon and alloy steels, titanium and titanium alloys. Establishes weld classes based on safety factor.

3.3.5 Nonmetallic Coatings

Process	Applicable Specification	Issuing Agency	Description and Intended Use
Alodine 600, 1200, 1500	171A4223 171A4441 156A8990 (AMS 2474) (MIL-C-5541)	GE/R GE/S GE/R SAE DOD	Processes for corrosion protection, low electrical resistance, and controlled emissivity.
Aluminum Hard Coating	AMS 2468 (AMS 2469)	SAE SAE	Dense abrasion resistant aluminium oxide.
Anodizing Coatings	MIL-A-8625	DOD	Corrosion resistant oxide film and base for other coatings.
Anodizing Magnesium	MIL-M-45202	DOD	Dow 17, HAE and other anodic treatments. Best combination of corrosion resistance and paint base.
Black Oxide Coating,	MIL-C-13924	DOD	Thin corrosion covering offering limited protection.
Carbon Black Pigmented Anodize	171A4227	GE/S	High emissivity coating.
Chemical Films, Aluminum	MIL-C-5541 (146A9303) (156A8990)	DOD GE/S GE/R	Chromate film, corrosion resistant Alodine 600, 1200, 1200S, Iridite 14, 14-2 (and about 30 others).
Chemical Films, Magnesium (Dow 7 and 9)	MIL-M-3171, Type 3 and 4	DOD	Corrosion resistant coatings and base for paint-type coatings.
Coating, Nylon, Application	S30050	GE/S	Application of lubricating coating for sliding surfaces such as temperature controller arms.
Dow 10	171A4437	GE/S	Low surface resistivity coating for magnesium.
Dow 19	147A1844	GE/R	Chemical touch-up finish for magnesium.

3.3.5 Nonmetallic Coatings (Cont'd)

Process	Applicable Specification	Issuing Agency	Description and Intended Use
Dow 23	171A4206	GE/S	Low surface resistivity coating for magnesium.
Passivation	147A1232	GE/R	Passivation of stainless steel (12% or higher chromium).
Phosphate Coatings, Ferrous Metals	MIL-P-16232	DOD	Heavy corrosion resistant coating.
Primer Application	MIL-P-6808	DOD	Priming with low moisture sensitivity, zinc chromate, corrosion inhibiting primer.
Urethane Compound, Thixotropic	171A4419	GE/S	Used as a conformal coating. Temperature range -70° to 300°F.
#47865 Black Paint	171A4448	GE/S	High emittance black coating.
SMRD 100	171A4564	GE/S	Spray application of a protective epoxy coating to separator springs.
Pyromark Grey	171A8251	GE/S	Application of grey thermal control coating blended from white and black paints.

3.3.6 Plating and Metallic Coatings

Process	Applicable Specification	Issuing Agency	Description and Intended Use
Aluminum Vapor Deposition	MIL-C-23217	DOD	Corrosion protection finish for ferrous alloys.
Chromium Electroplating	QQ-C-320	Federal	Wear and corrosion resistance.
Copper Electroplating	MIL-C-14550	DOD	For masking and to prevent diffusion.
Electroless Nickel-Phosphorous Plating	MIL-C-26074	DOD	Wear, abrasion and corrosion resistance.
Electroless Nickel-phosphorous Plating	171A4187	GE/S	Deployment mechanisms-supplement to above. Process for hardening the plating.
Gold Electroplating	MIL-G-45204	DOD	High electrical conductivity and low electrical contact resistance plus tarnish resistance.
Gold Electroplating	146A9269	GE/R	Low emissivity gold coating electroplated or vacuum deposited.
Gold Electroplating	147A1209	GE/R	Electroplating gold on stainless steel.
Nickel Electroplating	QQ-N-290	Federal	Wear, corrosion and abrasion resistance and appearance.
Nickel Plating Aluminum Tubes	171A4169	GE/S	Nickel plating on aluminum alloys for soldering and joint sealing.
Rhodium Plating	MIL-R-46085	DOD	Dense, non-porous coating for commutation.
Silver Electroplating	QQ-S-365	Federal	Increased solderability, corrosion protection and electrical properties.

3.3.6 Plating and Metallic Coatings (Cont'd)

Process	Applicable Specification	Issuing Agency	Description and Intended Use
Silver Electroplating	146A9269	GE/R	Electroplated or vapor deposited low emissivity silver coating.
Silver and Rhodium Electroplating	AMS 2413	SAE	Conductive surface for electrical contacts.
Tin-Dalic Plating	171A4431	GE/S	Selective plating.
Tin Electroplating	MIL-T-10727	DOD	Plating or hot dipping tin on ferrous or non-ferrous metals.

3.3.7 Resin Processing

Process	Applicable Specification	Issuing Agency	Description and Intended Use
Adhesive Bonding	128A5505	GE/R	Bonding with Dow Corning A-4000 Resin or MMM EC1357 adhesive.
Bonding	MIL-A-9067	DOD	Proc. and Insp. requirements of adhesive bonded parts including sandwich constructions.
Bonding (Epon Series)	171A4425	GE/S	Provides adhesion to aluminum, steel, magnesium and plastic surfaces.
Bonding (PD454, PD458, PD459)	147A1856 Type 1	GE/S	Includes bonding with clear epoxy adhesive used for optical and power conversion applications.
Bonding, Tape	171A4171	GE/S	Bonding with Schjeldahl GT heat-sealable adhesive tapes.
Bonding (Thermally Conductive)	171A4350	GE/S	Sealing, filleting or bonding with Eccobond 60L two component thermally conductive adhesive.
Encapsulating (MPC-52)	S30021	GE/M	Encapsulating with thermally conductive epoxy.
Impregnation of Non-ferrous Castings	MIL-STD-276	DOD	Aluminum alloy, magnesium alloy and copper alloy castings.
Surface Preparation Prior to Adhesive Bonding	171A4500 (147A1835)	GE/S GE/R	Several cleaning requirements prior to adhesive bonding for metals and non-metals.
RTV 566 A/B Processing	171A4576	GE/S	Processing and inspection requirements for using RTV 566 A/B (171A4575) for sealing, bonding, potting, and encapsulating.

3.3.8 Other Processes

Process	Applicable Specification	Issuing Agency	Description and Intended Use
Application of Shim Material	171A4193	GE/S	Process for application of epoxy material.
Brush Touch-Up (Dow Chemical Treatment No. 1)	118A1525	GE/M	Covers use of a brush-on chrome pickle used for touch-up purposes on magnesium surfaces.
Drawing Terms and Tolerances	118A1664	GE/M	General interpretation of terms and tolerances used on drawings.
Finishes and Coating Systems	118A1600	GE/M	Standard covering processes for preparation of surfaces, priming, finish coats, various materials, etc.
Glass Fiber-Epoxy Resin Laminates	146A9026	GE/S	Surface preparation, layup, and bonding procedures for glass fiber using Epon 815 or 828 and TETA.
Grease, Silicone CS-4073	171A4170 (171A8232)	GE/S GE/S	Procedure for application of silicone grease, CS-4073, as an interface filler for unbonded thermal joints.
Harness Definition	S30402	GE/S	Defines engineering data procedures and requirements for cables and harnesses. Defines Manufacturing and Quality Control activities required to conform to those requirements.
Identification Marking	118A1526	GE/M	Rubber stamping or stenciling (application of recommended epoxy base ink does not require coat of "Krylon" lacquer over ink marking.)

3.3.8 Other Processes (Cont'd)

Process	Applicable Specification	Issuing Agency	Description and Intended Use
Leakage Testing	147A1875	GE/S	Procedure using argon or helium mass spectrometer method.
Leakage Testing	147A1876	GE/S	Halogen leak detection procedure.
Leakage Testing	147A1877	GE/S	Radiflow leak detection procedure.
Lightening Hole 35° Flanged	118A1534	GE/M	Standard lightening hole sizes with shop capabilities for producing 35° flanged, round holes in sheet metal.
Liquid Sealant (Loctite)	156A9718	GE/R	Requirements for application of a liquid sealant compound.
Modules, Electronic	S30002	GE/M	Requirements for the assembly of welded "cordwood" electronic modules.
Preshrinking Aluminized Mylar	171A4156	GE/S	Preshrinking aluminized Mylar for insulation blankets.
Resiweld #7004	171A4516	GE/S	Application of epoxy adhesive for rigid or flexible bonding.
Swaging, Terminals Annealed	S30051	GE/S	Requirements for swaging turret and bifurcated annealed terminals on printed circuit boards and terminal boards.

3.3.8 Other Processes (Cont'd)

Process	Applicable Specification	Issuing Agency	Description and Intended Use
Vapor Deposited Al, Au, Cu	171A8222	GE/S	1.000-2.000Å thin film low emissivity deposit. Coating radiative properties highly dependent on texture, roughness of surface, and process. Used extensively in aerospace industry. Excellent property stability in space environment.
Wiring and Electrical	118A1645	GE/M	General requirements for wiring and electrical connections in electrical and electronic equipment.

4.0 QUALITY ASSURANCE PROVISIONS

Not Applicable

5.0 PREPARATION FOR DELIVERY

Not Applicable

6.0 NOTES

6.1 Abbreviations under "Issuing Agency":

American Society For Testing And Materials.....ASTM
Department of Defense.....DOD
General Electric Company.....GE
Engineering Services.....GE/ES
Philadelphia SD & RESD.....GE/M
Space Division.....GE/S
Re-Entry and Environmental Systems Division.....GE/R
General Services Administration.....Federal
National Aeronautics and Space Administration.....NASA
Society of Automotive Engineers.....SAE

SECTION 5

ERTS CONFIGURATION MANAGEMENT PLAN

SECTION 5

ERTS CONFIGURATION MANAGEMENT PLAN

5.1 PURPOSE AND SCOPE

This Configuration Management Plan meets the requirements and intent of GSFC Management Instruction No. 8040.1 (Configuration Management, dated 5 October 1967) for in-house and subcontractor designed hardware. It includes methods for:

1. The uniform identification of drawings, specifications, and associated documents.
2. The control of changes to documentation, including procedures required to maintain compatibility between ERTS and Nimbus documents.
3. The implementation of configuration accounting, through the issuance of the Configured Article List and other verification data.

Subcontractor configuration management practices will be reviewed for adequacy with respect to the objectives of this plan.

5.2 RESPONSIBILITY

Responsibility for configuration management decisions resides within the ERTS Program Office. The responsibility for the detailed execution of the Configuration Plan is the responsibility of the Configuration Management Office established within Product Assurance. Responsiveness to program policies and plan is achieved through interaction with the Performance Assurance Manager and by Program Office concurrence with Configuration Control Board (CCB) actions.

NOTE: An integrated Configuration Control Board serves both the ERTS and Nimbus Programs by providing control for changes affecting common documentation. This Configuration Control Board will review all changes to baselined documentation. Its membership is composed of representatives from Engineering, Manufacturing, and Product Assurance.

5.3 IMPLEMENTATION PLAN

5.3.1 GENERAL

Configuration management on the ERTS program will be divided into two stages separated by the establishment of a configuration baseline prior to the start of qualification testing or fabrication of deliverable flight hardware, whichever comes first. The configuration baseline is to be defined by a list of documents which are frozen upon issuance of the list by the Configuration Management Office based on Engineering design definitions. Equipment definitions will be frozen on a sequential basis. Upon issuance of the list, all documents listed thereon will be under formal change control requiring CCB (GE) approval.

5.3.1.1 Stage I Baseline

The approved ERTS System Specification will be used as the primary source document for the overall spacecraft performance and design requirements. The approved Observatory System Specification defines the design requirements baseline of the flight observatory. This approved Observatory System Specification will be placed under change control of the CCB. GSFC approval of the Observatory System Specification establishes the Stage I baseline. During the subsequent development of lower order specifications, drawings, preferred Parts and Materials Lists, etc., between the Stage I baseline and the Stage II baseline, these documents will be under change control by the developing organization. Monitoring will be carried out by configuration management to assure that changes are included in the drawings, specifications and interface control documents that govern production at the establishment of the Stage II baseline.

5.3.1.2 Stage II Baseline

The Stage II baseline is established by the issuance of a Configured Article List by the Configuration Management Office. This list provides the flight hardware "built to" requirements or the qualification "test to" requirements.

5.3.1.3 Baseline Controls

Figure 5.3.1-1 is a simplified chart showing the flow of change documentation as the ERTS Program progresses through Stages I and II. A list of ERTS Program Hardware is shown in Volume I, Section 5.2.6. These components will be placed under change control.

5.3.2 CHANGE CONTROL

The preceding paragraphs have shown the baselines upon which change control is based and how this control is implemented. The following paragraphs define the means for simplifying change effectivity and the functions of the various types of change documentation.

Effectivity is defined as the point in production when a design change is required to be incorporated into the hardware. It is normally specified by Engineering as either a desired or required point of introduction. Effectivity is analyzed by the CCB for the effect upon all operations. Once agreed to and placed on a change document effectivity becomes a schedule commitment, is binding on all parties, and will be the subject of verification by Product Assurance.

A configured article serial number is always specified as the effectivity for the change. Where the change is to be incorporated on two or more programs, the effective serial number for each program shall be specified.

Effectivity may be given in terms of one or more serial numbers. When a specific configured article is desired, only that serial number will be given and the change will be incorporated into only that number. When a change is required to be effective at specific serial and all units thereafter, it will be specified as "serial number 'x' and subs".

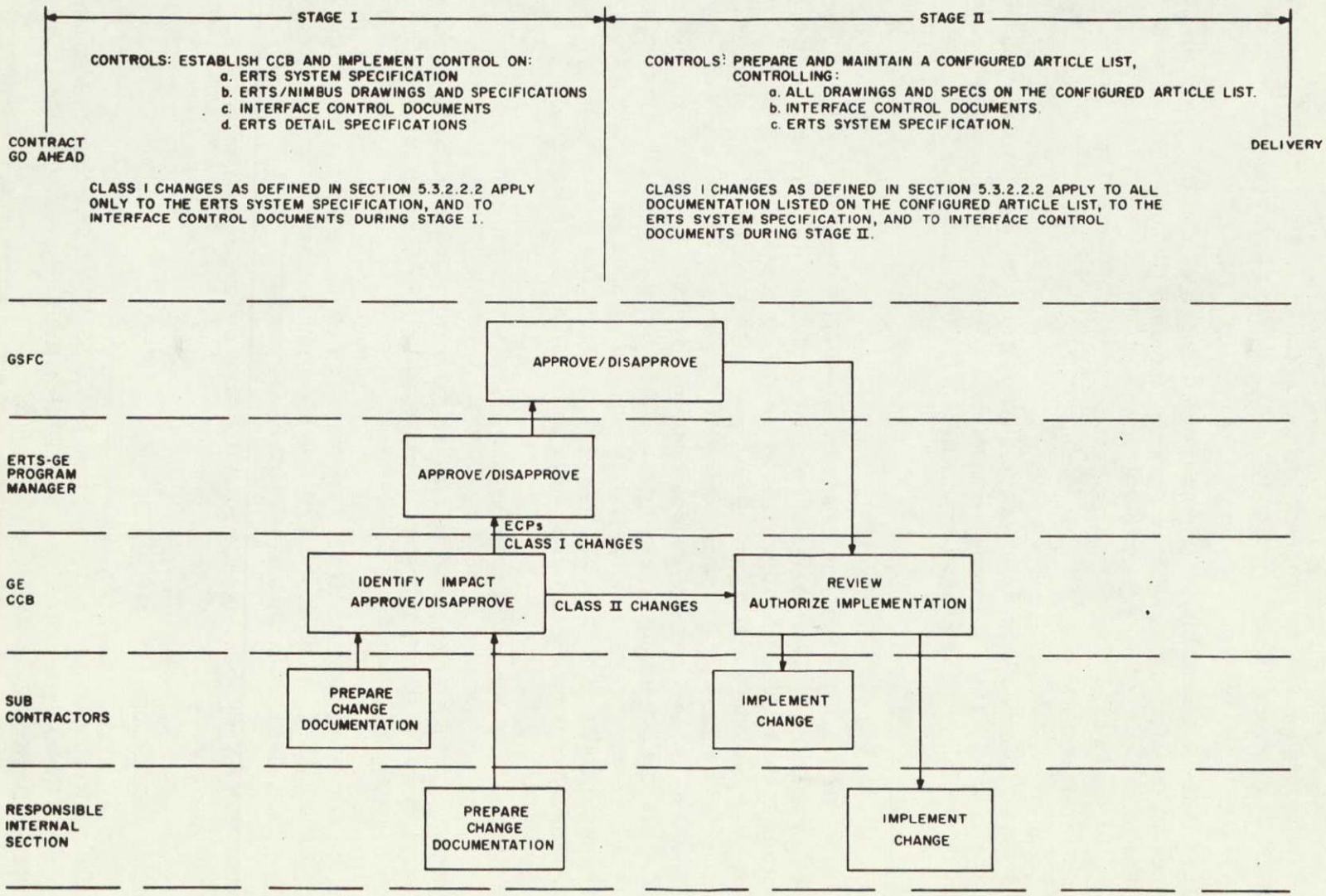

Figure 5.3.1-1. Simplified Change Information Flow Chart

Change control to documents common to the Nimbus Program will be as follows:

1. Nimbus drawings which are proposed for use on the ERTS Program are to be frozen at ERTS Contract go-ahead — frozen to the extent that no changes can be made without approval of the CCB.
2. Changes must be acceptable to both programs as signified by CCB approval. If changes are not acceptable to both programs, for which the change is mandatory, a new identification number shall be created.

5.3.2.1 Change Documentation

Except for Engineering Change Proposals (ECP's), subcontractors may have other documentation, by another name, serving the same purpose. Subcontractor documents will be reviewed early in Phase D to assure their applicability for the ERTS Program.

5.3.2.1.1 Change Notices

Change notices, (within GE Space Systems these are called Alteration Notices (AN's), are the documents used to describe in detail the actual change to various other documents (i.e., drawings, specifications, etc.) which are authorized by the AN approval. The AN also, by definition, authorizes change to the hardware as defined by the AN at the effectivity specified. The AN contains other information for use in analyzing the impact on cost, schedule, performance, etc., and is identified by the number of the document for which the change is proposed, plus a numerical suffix assigned in sequence. A separate AN is prepared for each document to be revised. This GE system results in identifying the hardware, such that it corresponds exactly to the drawing change notice (AN) to which it was made. Immediately upon approval, the AN's are transmitted to Engineering, Production, and Product Assurance for action.

The following types of AN's are used according to the desired action:

1. Emergency - An AN which requires special and accelerated handling to avoid work stoppage, rework, scrap, reprocurement, cancellation charges, retest, eliminate safety hazards, etc.
2. Compatability - An interim AN used to correct a drawing error to prevent the stoppage of manufacturing effort, due to a problem requiring an AN for resolution and not requiring a change to the basic design or function.
3. Routine - An AN which follows the normal routine and procedure for handling processing.

5.3.2.1.2 Engineering Change Proposal (ECP)

Engineering Change Proposals are used to propose to the GSFC-ERTS Program Manager all changes which affect the mission objectives, or affect contract price or schedule, subject to contract negotiation finalization.

ECP sequence numbers will be assigned and controlled by the Configuration Management Office which will maintain an ECP status record. ECP's will be prepared by Engineering in conjunction with the Configuration Management Office. They will be reviewed by the CCB and approved by the GE ERTS Program Manager, and submitted by him to the Customer (GSFC).

5.3.2.2 Drawing and Specification Change Control

5.3.2.2.1 Stage I

During the period between Stage I and Stage II baseline, only those drawings and specifications which have been baslined and those Nimbus drawings and specifications which have been identified for use on ERTS will be under CCB control. Other drawings and specifications will have their changes controlled by the developing organization.

5.3.2.2.2 Stage II

All changes during Stage II, after baseline establishment and issuance of the Configured Article List, require the approval of the CCB. Each proposed change will be analyzed for its impact on performance, cost, schedule, program requirements, reliability, safety, and subcontractor and experimenter functional and physical interfaces. Class I changes are all changes affecting the following, and require the preparation and submittal of ECP's to the CCB, normally prior to the preparation of detail change paper:

1. Baselined specifications, contract price or fee, contract weight, contract delivery, or contract test schedules
2. Interchangeability
3. Safety or reliability
4. Electrical interference to electronic equipment or electromagnetic radiation hazards
5. Preset adjustments to the extent that
   a. new item identification must be assigned
   b. operating limits are affected
6. Subcontractor, experimenter, or other agency interfaces
7. Operational computer programs which are deliverable items of the contract
8. Value Engineering.

Detail change paper (i.e., AN's) resulting from approved ECP's and those not affecting the above conditions will be submitted to the CCB for review and approval. Compatibility AN's approved by the responsible Engineer, Production Control, and Product Assurance will be submitted to the CCB within one working day. Change to the hardware may take place immediately. The CCB approval will be signified within one working day of receipt.

5.3.3 DRAWING PRACTICES

5.3.3.1 General

GE Space Systems drawing practices conform to the requirements of MIL-D-1000, Form 2. Uniform practices are prescribed in GE Space Systems Drafting Practices Manual. Practices unique to the Program will be inserted into the Manual, employing specially colored and annotated sheets. Subcontractor drawing practices will be reviewed for adequacy by the Configuration Management Office.

5.3.3.1.1 Existing Data

Engineering drawings and data previously prepared by a subcontractor to describe prior existing items/parts shall be submitted to GE Space Systems for review. If the previously prepared data is not reproducible in accordance with MIL-D-5480, the subcontractor will be notified by GE Space Systems to furnish modified or redrawn data in accordance with MIL-D-1000, Form 2. Existing data will not be redrawn solely to comply with MIL-D-1000.

5.3.3.1.2 Standard Parts

Engineering drawings and data shall not be prepared for Military or NASA standard items, and industrial or commercial standard items previously approved by the Military or NASA.

5.3.3.1.3 Drawing Parts List

Engineering or Associated Parts Lists shall be prepared to satisfy the requirements of MIL-Std-100.

5.3.3.2 Standard Configuration Identification Numbers

The following Configuration Identification Numbers shall be used to identify the configuration of configured article equipment:

1. Specification Identification Numbers
2. Serial Numbers
3. Drawing and Part Numbers
4. Code Identification Numbers.

The use of these four basic numbers will permit complete identification of the product as required for technical and contractual purposes. No other identification numbers will be used on the Program unless specified by GSFC.

5.3.3.3 Drawing Numbers

To ensure that there is no duplication of drawing numbers throughout the company it is GE's policy, and established practice, to control and assign all drawing numbers from a corporate source. These are assigned to departments and then, in blocks, to the functional sections by Space Systems Print Control & Reproduction (PC&R). These numbers conform to the

requirements of MIL-STD-100. Once assigned to a drawing, and once the drawing is released, that number is never reassigned to another drawing.

5.3.3.4 Specification Numbers

Specifications used on both Nimbus and ERTS will retain the Nimbus number. Specifications peculiar to ERTS will be assigned a new number. These numbers are controlled by Space Systems Print Control and Reproduction.

5.3.3.5 Item Identification

The drawing number assigned will identify only the drawing (which may contain one or more parts or assemblies). For example, XX-XXXXX1 is the number by which a drawing is identified, filed, controlled, requested (and in Space Systems becomes a part of the drawing change notice number) and is the permanent portion of the item identification. By the addition of "P1" or "G1" as a suffix, (XX-XXXXX1P1), the number becomes the discrete identify of the item (item identification) defined on the drawing, and will be physically marked on the item if possible. Parts-marking requirements are contained on the drawing. Any change to the suffix letter or number denotes a different and noninterchangeable item. Items with the same identification are interchangeable in regard to form, fit and function.

5.3.3.6 Re-Identification

New identification numbers are assigned when the part is changed in such a manner that it is no longer completely interchangeable with the previously manufactured hardware. Interchangeability can be affected if safety, performance, installation, durability, or physical and environmental interface are altered.

No new part identification number will be necessary if all parts, subassemblies or complete items will be modified to incorporate the change. However, if any hardware has been delivered, a new part identification number will be assigned. If a non-interchangeable change is not to be incorporated into all existing hardware, re-identification is required, see Figure 5.3.3-1. New identification will be accomplished by the addition of new groups or parts or a complete new drawing as determined by the drafting manager.

When drawings identified as common to both programs require a change that is not acceptable to both programs, the program requiring the change will create a new item identification. This will be accomplished by the addition of a new part or group, as applicable, to the drawing.

5.3.3.7 Engineering Release System

The Engineering Release System will reflect complete GE drawing usage/application data. The Engineering Release Record shall record changes to individual drawings in accordance with MIL-Std-100.

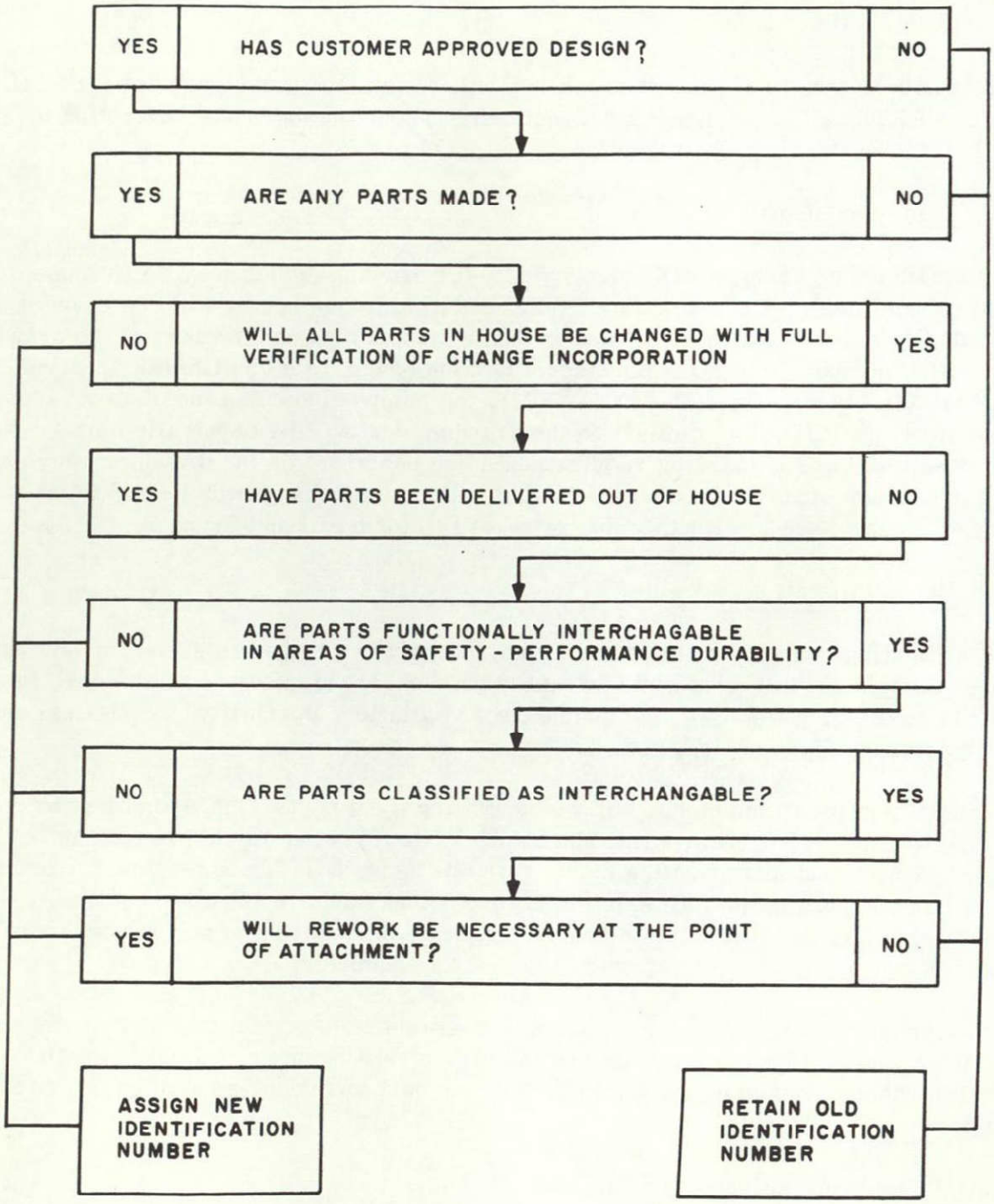

Figure 5.3.3-1. Reidentification Guide

In order to effect the release/issue of an engineering document, the responsible engineer will fill out the Space Systems Engineering Data Release (SEDR). A completed SEDR will accompany all drawings and specifications when forwarded to Print Control for release/issue. Subcontractors will be reviewed in order to establish their capability to conform to the document release requirements.

5.3.4 INTERFACE DEFINITION DOCUMENTS

Interface Definition Documentation will be used to define physical and functional requirements between the Observatory System and Government furnished sensors and the Observatory System and booster. Changes to these documents will be approved by the GE-CCB and submitted to GSFC, utilizing the ECP (see Section 5.3.2.1.2).

5.3.5 CONFIGURED ARTICLE LIST

A Configured Article List will be issued and maintained by the Configuration Management Officer at the start of Stage II. It will be updated and reissued monthly, or as required thereafter. It will list, by drawing and part number, nomenclature, revision symbol and revision date, the actual configuration of the configured article to be fabricated and tested. It will serve as the basis for the Product Assurance verification. It shall also contain the applicable specification interface definition documentation, and test procedure identification. The Configured Article List will serve as the basis for the Product Assurance verification of product integrity, a nd will be provided with the DD250 at delivery.

5.3.5.1 Hardware Verification

Each configured article and subordinate items contained therein and each spare will be inspected by Performance Assurance to verify meeting the definition shown on the Configured Article List and the Engineering Definition recorded. Verification will be recorded on Space Systems forms which will be included in the log book for each item.

SECTION 6

PROCESS ESTABLISHMENT AND CONTROL

SECTION 6

PROCESS ESTABLISHMENT AND CONTROL

6.1 INTRODUCTION

This section covers the activities necessary to adapt established manufacturing procedures to a new combination of requirements, such as void-free potting of new hardware configurations or a new compound, or employment of parallel gap welding techniques on flat pack leads. There are no new processes to be defined for use on the ERTS Program.

An established technique for successfully handling these new process variations for a program of this nature, covers certification of said processes for "Flight Fabrication Readiness" through a series of pragmatic evaluations and then controlling these and other fully established processes with frequent meaningful measurements and fail safe equipment indicators.

6.2 ORGANIZATIONAL MANAGEMENT

Process development at General Electric is an integrated effort of the following disciplines:

1. Design Engineering
2. Packaging Engineering
3. Manufacturing Process Producibility
4. Process Control

This team, organized to function early in ERTS program design phases, begins to function prior to or in parallel with engineering development and preproduction hardware fabrication.

The team defines the questionable processes, plans the steps required to evolve the solutions and then through a series of action item fulfillments, arrives at the desired set of process/material characteristics and controls. The total activity is then transposed into final documentation for use and control during fabrication.

Upon completion of appropriate training of operators and inspectors and the successful fabrication of process hardware samples, General Electric Management certifies the process as "Flight Fabrication Ready".

6.3 PROCESS CERTIFICATION - "FLIGHT FABRICATION READINESS"

General Electric's management technique for monitoring process development is accomplished by tracking the various action items identified by the previously mentioned process team and upon completion, certifying the related process.

When a given process has conclusively been proven capable of producing prime flight hardware within schedule without unusual quality or cost problems, a certification stating this fact is generated and signed by the managers of Product Assurance and Manufacturing.

6.4 APPROACH

6.4.1 DEVELOPMENT SEQUENCE

When the design requires the processing of new materials, places new performance requirements, or otherwise requires a process not previously employed and fully documented at General Electric, the responsible Engineering, Manufacturing, and Quality (EMQ) team mentioned above initiates work on this assignment. A definition of requirements is made as follows:

1. Performance Requirements - Strength, thermal stability, electrical integrity.
2. Material Limitations - Part lead composition, vacuum stability, pouring viscosity.
3. Hardware Limitations - Size, degree of complexity, inspection requirements, visual acceptance criteria.
4. Equipment Limitations and Controls - Availability, suitability, control instrumentation, operator skill.

With recognition of the requirements, the Physical Laboratory Development phase is at hand.

6.4.2 LABORATORY WORK

Work under laboratory direction is performed either in the Manufacturing Development Laboratory where shop-type facilities are available or, should the nature of activity be such, in the shop itself, under engineering direction. Four important elements are accomplished at this phase:

1. The process itself is established, equipment is identified/purchased, process parameters are evaluated and explored, material variability is evaluated, and control parameters are selected.
2. Preliminary manufacturing and engineering documentation is prepared. The process specification for engineering definition is verified, modified or written as required. If customer supplied, the requirements are analyzed and interpretations resolved with the customer. The preliminary manufacturing standing instructions are prepared. In this document, equipment, materials, and procedures to be utilized by shop personnel are documented. The Process Control Standing Instruction is written primarily to guide the inspection personnel with regard to specification interpretations, particular requirements necessitating special tooling, equipment, visual aides or instructions. These documents are signed-off by the customer of Engineering, Manufacturing, Quality team.

3. In the use of new processes, shop personnel (operators, inspectors) receive training and appropriate certification.

4. Preproduction or engineering hardware is fabricated by shop personnel under close surveillance of the technical personnel.

The hardware is carefully evaluated for defects and problems arising from producibility, process, and material inputs.

When required, changes such as specific weld schedule redevelopment, potting compound/catalyst, and plating on solder terminals may be affected.

All changes during the engineering development and preproduction fabrication phase are incorporated into the following documents:

1. Part and Material Specification
2. Process Specification
3. Manufacturing Standing Instructions
4. Process Control Standing Instructions
5. Manufacturing and Inspection Planning
6. Operator and Inspector Training/Certification

6.4.3 POLICY AND PROCEDURES

General Electric policy requires that all processes by fully documented, the processes be approved for program use, and where appropriate, operators and facilities be certified to perform the process. This policy is also applied to GE suppliers and subcontractors. Lists of certified vendors are maintained, based upon site evaluation of personnel, facilities, documentation and hardware produced.

6.4.4 OPERATOR AND INSPECTOR TRAINING AND CERTIFICATION

Special processes including operators and inspectors, and covering welding, soldering, finishing, adhesive bonding, conversion coating, potting and radiographic/penetrant inspection are required by department policy to be performed by personnel who have received training on a routine basis in the Manufacturing Reliability Training School.

Course content covers the specifications employed on a given process as well as the pertinent Manufacturing Standing Instructions.

Specialized applications of processes are taught in the manufacturing laboratories or shop area under manufacturing and engineering direction. Minor procedure changes are passed along at instructional meetings in shop areas. All inspectors of a process are also trained and certified in performing the process.

Certification is granted after successful course completion and passing of visual acquity tests. Recertification, as established by NASA, on a regular basis is maintained.

6.4.5 PROCESS CONTROL

During hardware fabrication, Process Control Engineering is responsible for assuring continuing process conformance, proper documented procedures and definitive corrective action in resolving discrepancies.

Controls as denoted below and found in the Quality Assurance portion of the MSI are implemented:

1. Process oriented equipment such as welding and wave soldering machines are monitored a minimum of twice per shift during operation.

   X - R charts of sample pull tests are maintained on module welding machines with a minimum of five samples per 4-hour interval recorded. Prior to pull, the samples must pass rigid visual criteria.

   Critical machine settings are monitored and recorded in log books either manually (once per four hour interval) or on a continuous basis employing chart recorders.

   Solder bath composition in the wave soldering machine is measured prior to use and weekly during the fabrication of prime hardware.

   All process machines are maintained and calibrated by Product Assurance to assure proper function. The weld machines are further qualified to the various weld schedules to be employed. Upon qualification, the machines are maintained as an entity (power supply, weld head) throughout the fabrication cycle. Requalification is required when the machine entity must be altered, or the machines have been recalibrated or major maintenance performed.

2. Manufacturing Standing Instructions, as well as the Manufacturing/Product Assurance planning is reviewed on the floor by Process Control Engineering as the project hardware is initially evolved through the fabrication cycle to assure continuity of activities and full inspector comprehension and coverage.

3. Nonconformance reports on discrepant hardware are reviewed by Process Control Engineering to determine the cause and to ensure that proper corrective action is delineated and implemented.

4. Defect summaries are tabulated, charted, and issued by program on a regular basis. Process Control further reviews the data for long term trends which may require corrective action.

5. On given critical processes, Process Control Engineering has generated a self audit procedure covering variables to ensure proper control. One such process, "Melt Thru" cross wire welding includes such variables as:

   a. Weld machine integrity and recorder controls

   b. Pull sample Macrograph evaluation

c. Planning fulfillment by floor personnel

d. Hardware quality

The audit is conducted daily with the check sheet signed by Process Control Engineering and placed in the weld station log book.

6.5 EXPERIENCE APPLICABLE TO THE ERTS PROGRAM

Previous General Electric Program experience has developed a disciplined proficiency in process development and control.

This proficiency was developed with time and a constant effort to correct and improve. Several previous problem areas and their solutions are delineated below:

1. In producing melt-thru (Lexan) cross wire welding matrices, it became apparent that the critical melt temperature of the Lexan material was being adjusted by operators to improve visual attributes.

   Although not reflected in sample pull tests, high resistance welds were being fabricated.

   The following corrective action was implemented:

   a. Operators/inspectors were retrained.

   b. The melt temperature is permanently determined on temperature recorders.

   c. Weld samples are subjected to a macrographic examination in addition to the visual and pull evaluations.

   d. "Lot acceptance" weld samples have been added for futher assurance. These samples are fabricated during the fabrication of a matrix lot thereby being more representative of the hardware produced.

2. The problem of producing a pneumatic system cleaned to a five micron level presented a significant challenge. While first attemps employed cleaning flows with several forms of jet washers and ultrasonic cleaning, it was found that continuous purging in the final rinse using freshly filtered solvent was most successful. Pressure vessels were cleaned with an internal lance with the solvent continuously filtered after preliminary ultrasonic cleaning. It became evident that minimum hardware handling and the simplest possible cleaning equipment was more effective and predictable in performance than complex equipment and excess handling.

3. It has been found on several types of gold plated terminals that heavy gold plating (greater than 50 millionths) employed to enhance solderability, has led to the formation of brittle solder joints through acicular gold tin eutectic in the solder adjacent to the plated terminal. These joints failed by cracking an appreciable time after fabrication. The corrective action to prevent reoccurrence of this problem was to control gold plating thickness on terminals to a maximum of 50 millionths and thus remain consistent with acceptable solderability practices.

An alternate method of overcoming this problem, when the first solution is not possible because of specifications for other constraints is the use of solder-wicking-solder sequence to remove a large portion of the excessive gold.

4. Another problem which had arisen was concerned with inadequate wetting in the solder cups of connector pins. To overcome this problem, the use of pre-tinned solder terminals and wire was adopted for all usage and temperature controlled soldering irons were introduced as standard in all solder assembly.

5. An effort to obtain void free potting and proper module imbedment by General Electric has led to the following process improvement:

   a. Selection of low viscosity, low exothermic potting materials.

   b. Elaborate first piece/tool tryout potting mold evaluations.

   c. Selection of a thermal-vacuum potting chamber.

   d. Use of TV X-rays (Picker) to rapidly determine potting clearance dimensions and voids.

6.6 ERTS SOLDERING PLAN

6.6.1 INTRODUCTION

General Electric policy procedures and specifications for soldered electrical connections are in conformance with NHB 5300.4 as required for the ERTS Program. That document and its predecessor, NPC 200-4 have been the basis of General Electric procedures for many years and have been utilized in all space vehicle hardware unless otherwise required.

6.6.2 APPLICABLE DOCUMENTS

Solder assembly for ERTS will be governed by several forms of General Electric documentation:

S30042 Engineering and Quality Standards for Electronic Equipment

S33128 Printed Circuit Board Assembly, Quality Acceptance Criteria for

S33172 Printed Circuit Board Design Requirements

S33173 Printed Circuit Board Acceptance Criteria

S33174 Printed Circuit Board Assembly, Design Requirements for

Quality Assurance Procedure 7.3 Hand Soldering, Control of

Quality Assurance Procedure 13.1 Certification of Training of Operators and Inspectors

6.6.3 DESIGN

Two of the mentioned documents, S33172 and S33174, respectively, define engineering design requirements for printed wiring boards themselves, and for the placement and attachment of parts onto the boards. These two standards are for the guidance of the design activity only, and they are not called out on engineering drawings. The designs themselves are subject to review by Quality Engineers for adherence to these design requirements. Also, a producibility review is conducted to assure that necessary clearances for soldering iron placement and inspection viewing exists. At this time, the outline of the manufacturing flow sheet is defined with the necessary fabrication and inspection sequences.

6.6.4 MATERIALS

All materials used in the design are specified in the applicable standards, engineering drawings, and are on the ERTS approved parts and materials list. This includes boards, terminals, electronic parts, solder, flux, cleaning solvents, and other manufacturing aids. Each of these materials is procured to the applicable specification, and objective test data on conformance to the specified parameters collected and evaluated prior to materials acceptance.

6.6.5 INSPECTION

The wiring boards when fabricated, but before the attachment of parts, are subject to inspection to the requirements of S33173 - "Printed Circuit Board Acceptance Criteria".

6.6.6 FABRICATION

The remaining standard S33128 - "Printed Circuit Board Assembly, Quality Acceptance Criteria for" - contains the information found in NHB 5300.4. It, along with the previously mentioned S33173, is specified on the engineering drawings and defines the processes to be utilized by shop personnel. The manufacturing instructions and the training courses for solder operators and inspectors are based on this document.

6.6.7 REWORK

Should rework be required, either because of the soldering operator's own inspection, or subsequent inspection and/or MRB action, all solder on the joint is removed by wicking the terminal clean and the joint resoldered to meet its initial requirements. All activity of this type will be performed within the scope of the ERTS Quality Program Plan.

6.6.8 CERTIFICATION AND TRAINING

General Electric's policy on the training and certification of operators and inspectors is covered by Quality Assurance Procedures 13.1 and 7.3. Training and examination of assembly personnel and inspectors involved in soldering is the responsibility of the Manufacturing Reliability Training Center. The recommendations for personnel certification by the instructors after course completion with written and practical demonstrations are combined

with the results of visual acquity examination for granting initial and recertification by Product Assurance. Loss of certification or retraining because of unsatisfactory performance is based upon the recommendation of Process Control Engineering.

SECTION 7
FAILURE ANALYSIS AND REPORTING

SECTION 7

FAILURE ANALYSIS AND REPORTING

Established failure reporting and response procedures, effectively used on current NASA programs will satisfy the requirements of the ERTS Program.

7.1 FAILURE REPORTING

A comprehensive failure reporting system utilizing the GE Nonconformance Report (Figure 7-1) and the GSFC Malfunction Report (Figures 7-2, 2 sheets) will be maintained throughout the fabrication and in-house testing phases of the Program. Quality Assurance Procedure 8.1 and Appendix A explain the details associated with the use of the Nonconformance Report (NR). The NR will be used to report all defects and failures occurring on GE hardware through testing at the sub-system level. The GSFC Malfunction Report (MR) will be used to report all malfunctions at the system level of testing and malfunctions of GFP hardware at all levels of test or inspection.

The MR will be generated by the Product Assurance test conductor or inspector in charge at the time of the malfunction. The completed report will be sent to Failure Analysis Engineering, where it is logged and checked for accuracy and completeness. Reproduced copies of this preliminary MR will be distributed to NASA/ERTS Program Office and in-house program personnel within 48 hours of failure verification.

Failure Analysis Engineering will be responsible for coordination of the analysis of the malfunction and implementation of required corrective action. When this has been completed, they will transcribe the pertinent information on the MR and obtain approval from the ERTS program office. Failure Analysis Engineering will then reproduce the reports and distribute them to NASA/ERTS Program Office (thru the GE program office) and in-house program personnel.

Monthly summary reports will be issued to detail the current status of Malfunction Reports (Figure 7-3).

7.2 FAILURE ANALYSIS

All failures of potted modules, components, and higher assemblies will be thoroughly investigated to determine their cause and effect. Complex and recurring failures will be subjected to a complete failure analysis conducted by the Failure Analysis Board (FAB). This Board, comprising the responsible Design Engineers, Quality Control Engineers and other related personnel, is directed by Failure Analysis Engineering. Depending upon the scope of the problem encountered, the FAB chairman may call upon any Department organization for technical support of the failure analysis effort.

Items submitted for Failure Analysis will be subjected to sufficient additional testing or examination to determine the exact reason for the failure and the corrective action

GENERAL ELECTRIC

SPACE SYSTEMS ORGANIZATION

NONCONFORMANCE REPORT

Page _____ of _____

1. Program	2. Date Oscur.	3. Location - Operation		4. Contract No.	5. SO No.	6. Rel. NR Nos.	7.
8. Item Insp/Tested		9. Dwg. No. AN		10. S/N	11. Supplier & Code No.	12. Buyer	13. P.C. Code
14. Failed Item		15. Dwg. No. AN		16. S/N	17. Supplier & Code No.	18. Vehicle No.	19.
20. Test/Insp. Spec.	Para.	21. Accrued Time Hrs.	Min. Cycles	22. Environment	23. Level	24. Type Test/Insp	25.
26. PO/Job. No.	27. Lot No.	28. Lot Size	29. No. Insp.	30. No. Rej.	31. Last Oper.	32. Source Insp. ☐ Govt. ☐ GE	33. BOI

34. Description of Nonconformance

35. Prelim Disp Code	36. Resp.	37. Date & Stamp

38. Originator Date

39. Validated by Date

40. Disposition Instructions

41. Problem Causes & Corrective Action Statement

Corrective Action Designator Date

APPROVALS:	42. Engineering Date	43. Quality Date	44. Customer Date	45. Recurrency No.

Form 992A6 (Rev. 6/68)

Figure 7-1. GE Nonconformance Report Form

GSFC MALFUNCTION REPORT

NOB 00919

(1) Project | (2) Spacecraft | (3) Operation | (4) Units 1 ☐ Hrs 2 ☐ Cys

(5) System or Experiment | (6) Date & Time of Malfunction Yr Mo Day Time | (7) Date of Report Mo Day | (8) Critical 1 ☐ Yes 2 ☐ No

NAME	IDENTIFICATION NUMBER	SERIAL NUMBER	MANUFACTURER
(9) Component			
(10) Assembly			
(11) Sub-Assembly			
(12) Part	Manufacturers Part Number	Circuit Des.	

(13) Malfunction Occurred During: 1 ☐ Qualification Test 2 ☐ Acceptance Test 3 ☐ Integration Test 4 ☐ Pre Launch 5 ☐ Launch Operations 6 ☐ System Test 7 ☐ Bench Test 8 ☐ Post Launch

(14) Environment When Failed: 1 ☐ Acceleration 2 ☐ Shock 3 ☐ Thermal-Vacuum 4 ☐ Temperature 5 ☐ Humidity 6 ☐ Vibration 7 ☐ Ambient 8 ☐ Acoustic

(15) Action to be Taken on Failed Unit:

Document Number that Authorized Failure Analysis:

(16) REFERENCE

Spacecraft Log Book # _____ Page _____ Test Procedure _____ Para _____

(17) Description of the Malfunction:

(18) Originator: | Phone: | Organization:

Do Not Write Below This Line

INSTRUCTIONS

(1) Originator – Fill in blocks (1) through (18), with all known information, as defined in instructions on the back of this form.

(2) Distribute copies in accordance with project directions.

Figure 7-2. GSFC Malfunction Report Form (Sheet 1 of 2)

GSFC MALFUNCTION REPORT NO. B 00919

(1) Project | (2) Spacecraft | (3) Operation | (4) Units 1 ☐ Hrs 2 ☐ Cys

(5) System or Experiment | (6) Date & Time of Malfunction Yr Mo Day Time | (7) Date of Report Mo Day | (8) Critical 1 ☐ Yes 2 ☐ No

NAME	IDENTIFICATION NUMBER	SERIAL NUMBER	MANUFACTURER
(9) Component			
(10) Assembly			
(11) Sub-Assembly			
(12) Part	Manufacturers Part Number		Circuit Des.

(13) Malfunction Occurred During: 1 ☐ Qualification Test 2 ☐ Acceptance Test 3 ☐ Integration Test 4 ☐ Pre Launch 5 ☐ Launch Operations 6 ☐ System Test 7 ☐ Bench Test 8 ☐ Post Launch

(14) Environment When Failed: 1 ☐ Acceleration 2 ☐ Shock 3 ☐ Thermal-Vacuum 4 ☐ Temperature 5 ☐ Humidity 6 ☐ Vibration 7 ☐ Ambient 8 ☐ Acoustic

(15) Action to be Taken on Failed Unit:

Document Number that Authorized Failure Analysis:

(16) REFERENCE

Spacecraft Log Book # _____ Page _____ Test Procedure _____ Para _____

(17) Description of the Malfunction:

(18) Originator: | Phone: | Organization:

Do Not Write in This Space

(19) Cause of the Malfunction:

Do Not Write in This Space

(20) Corrective Action Taken:

If Corrective Action is Required on Other Units, List Units:

Do Not Write in This Space

(21) Failure Analysis Performed? 1 ☐ Yes 2 ☐ No — Organization That Performed Failure Analysis _____ Failure Analysis Report Number _____ Date _____

(22) Rework of Unit: 1 ☐ Repaired 2 ☐ Modified 3 ☐ Discarded — Date _____ — Organization that Performed Rework _____

(23) Is Retest Required? 1 ☐ Yes 2 ☐ No — If Yes, State Retest Requirements _____

(24) Retest Results: 1 ☐ Satisfactory 2 ☐ Unsatisfactory — Remarks:

(25) Unit May Be Used For: 1 ☐ Flight 2 ☐ Test Only

Yr	Mo	Day	Date MR Closed	GSFC Project Approval	GSFC MRRT Approval Date	Contractor Approval Date

Figure 7-2. GSFC Malfunction Report Form (Sheet 2 of 2)

REPORT NUMBER AND DATE	REFERENCE DOCUMENT	DESCRIPTION	STATUS	DATE CLOSED
C00343 5/29/69	CCBD# 0802	ACS Assembly S/N D03 (FLT) 1. Defective inserts 2. Temporary hardware used for vibration test	1. Defective inserts were repaired 2. Temporary screws were removed after vibration test. CLOSED	10/28/69
C00344 5/29/69	CCBD# 0789	ACS Assembly S/N D03 (FLT) Mechanical interference.	Acceptable as is. FHC to revise drawings.	
C00345 6/3/69	CCBD# 0790	Corner Support Angle (FLT) Angle improperly fastened to structure.	Rework per drawing.	
C00348 6/4/69	PR# DF048 CCBD# 0793	Pitch Momentum Bias Test (FLT) Pitch telemetry data out of spec. Systems test data indicates procedure error.	Readings are acceptable. DTP 1421-D-034 was revised. CLOSED	10/22/69
C00349 6/4/69	PR# DF049 CCBD# 0794	Telemetry Test (FLT) RSAD housing pressure telemetry out of spec.	Acceptable as is. CLOSED	8/5/69
C00350 6/5/69	CCBD# 0795	ACS Structure S/N D03 (FLT) Test cable insulation worn away due to vibration.	Abraded area was wrapped with silicone tape. Rubbing surfaces were repositioned. CLOSED	8/5/69
C00351 6/6/69	PR# DF050 CCBD# 0796	IR Stimulator Cable S/N OK523 (BTE) Roll recorder not functioning.	Cables repaired. Operation satisfactory. CLOSED	8/5/69

Figure 7-3. Typical Malfunction Report

necessary to eliminate this type of problem. If necessary, the item will be disssected in the in-house facility best equipped for the necessary operation, under the direct control of the FAB chairman. The conveniently situated facilities of the Space Sciences Laboratory can also be employed in this effort, as can those of the uniquely equipped Parts Laboratory.

At the completion of each analysis, a comprehensive Failure Analysis Report (Figure 7-4) will be issued to document the history, analysis activities, conclusions, and corrective actions resulting from this activity. The assigned corrective action items will be monitored to assure accurate completion. Failure Analysis Supplements (Figure 7-5) will be issued to report significant progress and accomplishment of these items. The incomplete corrective action items will be published in an Open Action Item Summary Report Table 7-1 distributed to the responsible individuals, their managers, and interested Program personnel.

Failure Summary Reports (Figure 7-6) will be issued bi-monthly throughout the life of the Program and will provide a complete cumulative history of all program failures occurring prior to each date of issuance. These Summary Reports will include the date and conditions at the time of failure, a brief failure description, a summary of the analysis, conclusions, and corrective action for each failure occurrence (whether the failure has been covered by a Failure Analysis Report or was merely investigated). Any items not complete at the time of publication will be updated in subsequent issues.

Copies of all Failure Analysis Reports, Failure Analysis Supplements, and Failure Summary Reports will be distributed to NASA/ERTS Program Office immediately after completion.

Since our primary goal is to produce reliable hardware within time and funding limitations, the Failure Analysis Board will be especially responsive to all problems affecting costs, schedules, or hardware performance. All analyses will be conducted within a minimum time after failure to allow prompt correction of the problem area and continued production of quality hardware.

7.3 SUBCONTRACTOR CONTROL

The procedures described for in-house failure reporting and failure analysis will be essentially imposed on all major sub-contractors, with the exception that GE-SSO will initiate and control all Malfunction Reporting activities. SSO will also provide failure analysis support and interface with NASA-GSFC as required.

GENERAL ELECTRIC

SPACE SYSTEMS

MISSILE AND SPACE DIVISION

Valley Forge Space Technology Center

FAILURE ANALYSIS REPORT

468-D-6

Issuing Organization Failure Analysis Engineering		Program Nimbus D	Date 10/3/69
Equipment Name Temperature Controller		STATUS ☒ Continuing ☐ Final	
Drawing Number 47E213283-G1	Serial Number 5962987		
Manufacturer GE-SSO	Failure Report Number NR 24548	Failure Date 30 July 1969	

BACKGROUND

Temperature Controller S/N 5962987 failed to meet the requirements of thermal vacuum calibration designated in Paragraph 3.1 of SI 236,854. The transformer output did not respond as environmental temperature was altered from 13°C to 35°C. Observation of the mechanical linkage external to the primary bellows indicated the bellows extension rod to be immobile. Repetition of the calibration at atmospheric pressure verified the malfunctioning condition.

ANALYSES

The extension rod and rear bearing support of the primary bellows assembly was removed to permit examination of the shaft and bearing inner surface. A hard set pinkish colored compound, determined to be Grade A Loctite, was found caked in and around the bearing. The shaft was rigidly siezed. Subsequent to shaft removal it was observed that a large deposit of Loctite coated the inner surface of the split sleeve bearing. Figures 1 and 2 picture the Loctite deposits.

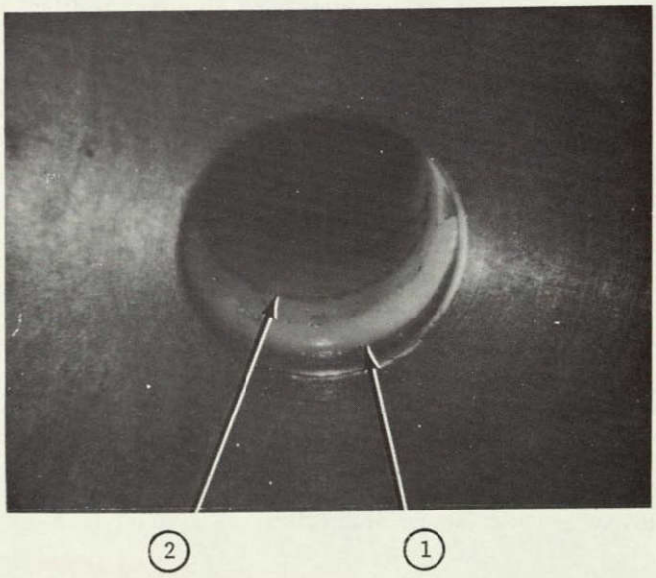

Figure #1 - Overall view of bearing and bearing support highlights
(1) Teflon bearing
(2) Loctite deposit on inner surface.

Figure 7-4. Typical Failure Analysis Report

11 February 1970

GENERAL ELECTRIC

SPACE SYSTEMS

MISSILE AND SPACE DIVISION

Valley Forge Space Technology Center

FAILURE ANALYSIS SUPPLEMENT NO. 1

468-D-6

Issuing Organization		Program	Date
Failure Analysis Engineering		Nimbus D	10/29/69
Equipment Name Temperature Controller		STATUS	☐ Continuing ☒ Final
Drawing Number 47E213283 - G2	Serial Number 5962987		

Written replies to Action Items defined in the main body of the report have been received. Briefly summarized:

Action Item #1 - "Review current manufacturing and quality control planning documents for temperature controllers and assure that they are revised to incorporate changes for Nimbus B controllers with respect to Loctite problem".

Manufacturing and Quality Planning documents were revised 26 February 1969 (Revision 2). The quality planning revision added black-light inspection for excessive Loctite deposits. The assembly of the S/N 5962987 unit used a set of planning which consisted of sheets 1 thru 4 of the Revision 2 planning and sheets 5 thru 10 of unrevised planning. The operation requiring black-light inspection appeared on sheet 8, Revision 2, and was not included in the planning set which was used. Application of Loctite to the unit was dated 11 March 1969 on the planning.

The cause for the intermingling of revised and unrevised planning and consequent deletion of black-light inspection is unknown. However, this confusion should not recur on future assemblies as only the revised planning masters now exist on file.

Action Item #2 - "Revise note 16 on Sensor Plate Assembly dwg. (GE dwg. 47E213283) to more clearly define area of application and warn against excessive amounts." The following sentence was added to note 16: "Remove any excess Loctite which would inhibit bellows shaft operation."

Figure 7-5. Typical Failure Analysis Supplement

TABLE 7-1. TYPICAL OPEN ACTION ITEM SUMMARY REPORT

Nimbus

Failure Analysis Report	Action Item	Responsibility	Assigned	Date Due	Comments
432-N-149	Notify ADC of the findings of the report, and obtain a copy of their analysis.	E. Emery	2/7/69	3/7/69	Complete
392-N-146	Report the results of the analysis of the contaminants washed from the main rotor and motor bearings.	G. McKinley	2/10/69	2/14/69	Late
	Evaluate the practicability of monitoring for leakage during thermal-vacuum testing.	R. Stanhouse	2/10/69	3/7/69	
386-N-143	Report the results of the engineering review of bolometer handling and testing procedures.	R. Stanhouse	3/4/69	3/21/69	

RELIABILITY ASSURANCE ENGINEERING

GENERAL ELECTRIC

Gyro Logic Unit

DRAWING NUMBER 47E214 800G1

MANUFACTURER GE-SSO

O A O FAILURE SUMMARY

FAILURE			TEST		FAILURE INVESTIGATION		REFERENCE	
REPORT NO.	DATE	SERIAL NO.	TYPE	ENVIRONMENT	DESCRIPTION	CONCLUSION	DOCUMENTATION	CORRECTIVE ACTION / RESOLUTION
NR 13285	3/13/68	5962510	Preliminary	Ambient	Unable to activate Buffer Module A2, Panel 6. Open circuit from J1014-55 to ground was noted. Resistance should measure approximately 13,000 ohms.	Troubleshooting revealed that wire numbers 67 and 68 were not installed on Panel A6. Additional circuitry had been designed but had not been fully installed.	DN 47D214822, AN 1.	AN 1 of DN 47D214822 (Panel 6) was incorporated.
NR 13292	3/19/68	5962510	Preliminary	Ambient	Unable to switch Relay Driver A4-4, Panel 2.	A wire was connected to Pin E21 on Panel 7 which should have been connected to Pin E19 on Panel 7. No damage was done to the GLU.		The unit was reworked to correct the wiring.
NR 8348	8/4/68	5962511	Preliminary	Ambient	This unit failed the continuity test (per paragraph 4.2.1.3 of S.I. 249334).	Troubleshooting revealed loose terminal connections at FL8-B and FL9-B.		The red lead was soldered to A9 FL8-B and the black lead was soldered to A9 FL9-B.
NR 8053	8/7/68	5962511	Acceptance	Ambient	Mechanical interference between the GLU and the Shock, Vibration, and Acceleration (SVA) fixture prevented the installation of all ten mounting screws.	A discrepant hole pattern existed in the SVA fixture, and a special assembly procedure was required for attaching the Filter Box to the GLU.	FAR 364-C-87	The SVA fixture was reworked. A special assembly procedure was written.
NR 7488	8/19/68	5795512	Acceptance	Ambient (Post-Vibration)	The voltage at TP-6 was drifting between -4.2 and +5.9 VDC. Specifications require +6 to +12 VDC.	[illegible] indicated a fault in the [illegible] C421 diode pair of Module A3, Panel 4, [illegible]	[illegible] 366-C-89	The module was replaced. See NR [illegible]476.
NR 7581	8/22/68	5962511	Acceptance	Ambient	Power was incorrectly applied to the GLU circuitry. When the -10 volt DC power supply ammeter nearly pegged and the voltmeter dropped almost to 0 VDC, the supplies were shut down.	The problem was traced to a miswired power [illegible] connector. No permanent damage was incurred by the GLU.	[illegible]R 376-C-9.	The power cable connector was rewired correctly and the GLU circuitry was retested satisfactorily.
NR 7586	8/25/68	5962511	Acceptance	Thermal Vacuum 50°F	The outputs at S3-5, S3-6, S2-10, S2-11, S2-20, and S2-21 were out of specification while testing to paragraph 4.2.4.4 of S.I. 249334.	[illegible] that the long [illegible] loading [illegible] from the [illegible]		The problem was corrected by changing the amplitude of the pulse from 9 volts to 12 volts.

6.

Figure 7-6. Typical Open Action Item Summary Report

SECTION 8.

COMPLIANCE OF EXISTING HARDWARE TO ERTS REQUIREMENTS

SECTION 8

COMPLIANCE OF EXISTING HARDWARE TO ERTS REQUIREMENTS

8.1 INTRODUCTION

The use of existing hardware on the ERTS program is presently limited to flight backup units which are common to both Nimbus and ERTS. These items are identified in Table 8.1-1 with the source and previous program usage indicated. All of the items except the Telemetry conversion circuit were originally supplied as GFE by NASA-GSFC for the Nimbus D program. For these items which are common to Nimbus E&F and the ERTS program, General Electric is purchasing the hardware from the same sources and to identical requirements used by NASA-GSFC. This approach is taken to capitalize on proven reliability, quality and test programs established on the Nimbus programs. This approach applies to the flight units for the ERTS Program as well as the common spares units.

Table 8.1-1. Flight Backup Units Common to Both Nimbus and ERTS

Power Subsystem	Previous Useage	Source
Storage Modules	Nimbus B/D	RCA
Power Control and Regulator Model	Nimbus B/D	RCA
Command and Data Handling Subsystem		
PCM Telemetry Processor	Nimbus D	Radiation Inc.
Command Clock	Nimbus D	Cal Comp
Attitude Control Subsystem		
Pitch Flywheel	Nimbus D	Bendix
Yaw Flywheel	Nimbus D	Bendix
Pneumatics Assembly	Nimbus D	TRW
Solar Array Drive	Nimbus D	TRW
Rate Measuring Package	Nimbus D	Sperry Rand
Yaw Rate Gyro	Nimbus D	Nortronics
Roll React. Wheel Scanner	Nimbus D	Bendix
Scanner Processor	Nimbus D	Ithaco
Telemetry Conversion Circuit	Nimbus B/D	GE/SSO

8.2 QUALITY REQUIREMENTS

In evaluating the quality requirements on existing hardware as compared to the ERTS quality requirements, it must be remembered that the quality requirements being imposed are by definition identical to those requirements imposed by NASA-GSFC on the subcontractors used for the Nimbus D program. General Electric must assume that these requirements were compatible with the NASA-GSFC requirements on General Electric for its portion of the Nimbus D program. The requirements on GE as specified in S-450-P-1A, GSFC Specification, Quality and Reliability Provisions for Nimbus D Procurements were implemented

through quality assurance procedures which adhere to NPC 200-2 and any program unique requirements were defined in the Nimbus Quality Program Plan. Implementation of these quality requirements has resulted in inspection planning, manufacturing instructions, test procedures, defect reporting, MRB practices and other performance assurance disciplines that are consistent with those imposed by NHB 5300.4 (1B), the ERTS quality requirements document. These same requirements will be implemented on the Telemetry conversion circuits, the single GE fabricated item utilized as a common spare between Nimbus and ERTS.

8.3 TEST LEVELS EVALUATION

An evaluation was also made of the test levels utilized for Nimbus flight components (and proposed for use on ERTS components that are of existing Nimbus design) as compared to the ERTS program requirements as reflected in S-320-G-1, General Environmental Test Specification for Spacecraft and Components. The detailed results of this evaluation and the proposed test approach for the ERTS program is given in Volume II, Section 10 of the ERTS Study Final Report. In summary, General Electric is proposing a test program for components in conformance with S-320-G-1 except for the areas shown in Table 8.3-1.

8.4 HARDWARE QUALIFICATION STATUS

As previously stated, the components supplied for Nimbus D as NASA-GFE will be purchased for the ERTS program as identical components with in-place, proven test programs. These components are considered qualified for flight based on their history developed from the Nimbus program. Due to the demonstrated adequacy of these components and the fact that the design, fabrication, inspection, test and overall quality control of these components remain unchanged, neither development or qualification tests are considered necessary.

8.5 SPARES QUALIFICATION STATUS

It is concluded that the Nimbus flight backup hardware being considered as common spares is acceptable from a quality and test standpoint. Decisions pertaining to final acceptance or rejections of specific components will be made by the Integrated Test Program Board per Specification SVS-7739, the ERTS environmental test requirements document.

Table 8.3-1. GE Exceptions to Specification S-320-G-1

Test Requirement	S-320-G-1 Reference Paragraph	GE Proposal
Weight and Center of Gravity	3.1.1 (Qual only)	GE proposes to determine center of gravity of components by analysis.
Magnetic Field Measurement	3.1.2 and 3.1.10 (Qual only)	GE does not propose to do magnetic field measurements. The spacecraft will include a magnetic compensation network.
Temperature, Storage	3.1.5 (Qual only)	As permitted per specification, tests will not be conducted based upon suitable component packaging and environmental control being provided.
Temperature Operation	3.1.5 (Qual only)	This test will be combined with the thermal vacuum tests. Temperature limits vary with component location on the spacecraft, using thermal analysis and test experience.
Humidity	3.15 (Qual only)	Test will be deleted as permitted per specification with suitable packaging and storage control.
Vibration (sine)	3.1.6.5 (Qual only)	GE proposes different vibration levels dependent upon component mounting location based upon Nimbus experience. Both sine and random have been proposed for acceptance.
Vibration (Random)	3.1.6.5 (Qual) 3.2.3.2 (Acceptance)	GE proposes different levels depending upon component locations. The proposed levels have been developed through several years test and analysis on Nimbus spacecraft.
Shock	3.1.6.5 option 1 (Qual only)	For most components, the high frequency sine vibration test applies. Components containing pyros will require shock testing. This can be accomplished by the spacecraft pyro firing tests.
Acoustic Noise	3.1.6.5 option 2 (Qual only)	The optional acoustic test will not be substituted for random vibration. Components already qualified by random vibration test will not be requalified.
Electromagnetic Interference	3.1.9 Qual 3.2.5 Acceptance	All new designs will be to the EMC design specification and the EMC plan. Existing flight proven components will not be requalified to the full MSFC-Spec-279, unless problems are encountered in the development bench integration test and bench acceptance tests. For acceptance tests, the EMC tests will be identified in the component specification. Special attention will be given to logic circuits susceptible to malfunctions due to transients and other electrical noise.

SECTION 9

RELIABILITY PROGRAM PLAN

SECTION 9

RELIABILITY

9.1 INTRODUCTION

The ERTS reliability program, as set forth in the following sections, is derived from NASA Reliability Publication NPC250-1.

9.1.1 SCOPE

This reliability program plan provides definition and description of the reliability tasks to be conducted by the General Electric Company-Space Systems and its subcontractors on the ERTS A and B Observatory Spacecraft. Detailed implementation by subsystem is further defined in the individual subsystem volumes of the Phase D proposal.

Sections in this Reliability Program Plan are numbered to correspond to paragraphs of NPC250-1, at least to the level of first indenture (i.e., x.x).

Note: The reliability plan for the ERTS ground data handling system is defined in the ERTS GDHS reliability plan.

9.1.2 APPLICABILITY

Reliability program requirements for the ERTS A and B Observatory Spacecraft shall be as prescribed in the work statement of the contract and as detailed in the approved Reliability Program Plan (as defined in NPC250-1, para. 2.2.4).

9.1.3 RELATIONSHIP TO OTHER CONTRACT REQUIREMENTS

The task requirements described in this plan have been carefully integrated with requirements delineated in comparison plans (e.g., Configuration Management Plan, Quality Program Plan, etc.) to assure that no duplication of effort is prescribed, and, from the other point of view, to assure that all tasks required for the delivery of reliable hardware have been accounted for.

9.1.4 ACTIONS AND PREROGATIVES OF NASA/GSFC

9.1.4.1 General

Any reliability program data generated under the ERTS Program contract shall be available to NASA/GSFC, or their designated representatives, for examination and evaluation at the GE-Space Systems facility. Submission of reliability program data to NASA/GSFC for reveiw and/or approval shall be as prescribed in the Data Delivery Schedule of the Work Breakdown Statement governing the Program.

9.1.4.2 Independent Reliability Assessment Contractor

GE will cooperate with NASA/GSFC's Independent Reliability Assessment Contractor by providing them free access to ERTS work areas and reliability program data.

9.1.5 APPROACH

The ERTS program philosophy for achieving a high-reliability, long-life space system is a reliability program which emphasizes the following points:

1. Recognition that the inherent system reliability and life are established by the basic design; hence, a need for primary reliability attention during the design and development phase of the program and continuing throughout the program life.

2. Recognition that operational achievement of reliability and life is a direct function of the detailed attention given to the hardware, fabrication processes, test procedures and handling. That is, a team effort is required to achieve the reliability initially designed into the hardware - involving many more groups than are classically associated with "reliability."

3. Establishment of a management planning and control system which permits current and constant visibility into all aspects of program risk and the various functions that influence reliability including identification and positive feedback of critical reliability problem areas and control of corrective actions.

In order to implement this basic philosophy, General Electric Space Systems maintains a strong, technically oriented reliability program with implementation in a manner which minimizes communication delay and enhances the flow of information critical to establishing and maintaining high reliability and long life.

The key to success of this selected approach is the assignment of reliability task responsibility to those groups having direct responsibility for performance of related tasks. Section 9.2.1 "Organization" and 9.2.4 "Reliability Program Control and Monitoring" provide additional detail regarding the GE approach to implementing an effective reliability program.

9.1.6 APPROVAL AND REVIEW BY NASA/GSFC

See Section 9.1.4.

9.2 PROGRAM MANAGEMENT

9.2.1 ORGANIZATION

Overall management visibility into the reliability aspects of the program is maintained via regular reliability reporting techniques and a single focal point is provided in the Manager, ERTS Reliability reporting to the Performance Assurance Manager on the ERTS Program Manager's staff. This provides a direct line of communication to the Program Manager concerning all aspects of the implementation of the reliability program and assures immediate management attention to any situation which appears to jeopardize the achievement of a high reliability, long-life space vehicle system.

The majority of the "Reliability Engineering" tasks, described in Section 3 herein, come under the cognizance of a single group, Reliability Engineering. Experienced engineers

from this group are assigned under technical directive of the ERTS Reliability Manager to work with the ERTS design engineers and provide effort required to assure incorporation of design reliability requirements into the system. Strategically, incorporation of reliability as an in-line function of the design process, with necessary support and standardization of practices provided via these assigned specialists, emphasizes reliability awareness in the design personnel - those responsible for establishing the inherent reliability and life capabilities of the system.

In this manner, control of the reliability engineering program for ERTS is maintained by the Manager, ERTS Reliability, and the location of his assigned personnel in the same areas as the program design team assures effective communication and consideration of reliability and life as essential design parameters. The Reliability Engineering Manager has cognizance over the ERTS Engineering Design Review program, thus providing not only in-process cognizance of reliability through his personnel assigned to the ERTS program but also the periodic assessment of design progress offered by the review function.

As the design is finalized and is transformed into hardware, emphasis shifts from creating a reliable, long-life product to assuring that the inherent reliability and life design into the product are achieved. This "assurance" is gained through an essentially continuous monitoring process comparing, at every stage of the hardware development, actual versus anticipated performance. Fundamental information for this process is inspection and test data with the objective being the identification of real or potential trouble spots and the documenting of sufficient information to permit timely and effective testing.

The reliability program activities for ERTS are thus planned to dovetail smoothly with other activities such as Quality Control, Test, and Configuration Management to provide overall performance assurance.

At the outset of the program, the Manager, ERTS Reliability reviews existing reliability instructions and procedures in light of the unique requirements of the ERTS program. In-place procedures are used whenever possible to capitalize on familiarity with existing methods of operation. (See, for example, Appendix A regarding the selection of existing Reliability Assurance and Quality Assurance Procedures).

Where in-place procedures do not satisfy the needs of the ERTS Program, they are supplemented or superceded through the mechanism of program directives.

The Manager, ERTS Reliability serves as the Program Manager's focal single point for the overall ERTS reliability program. In turn, he compliments the GE Space Systems internal reliability program through groups either assigned to or otherwise supporting the ERTS Program and also exercises authority over all subcontractor reliability program activities as discussed in Section 9.2.6.

Figure 9.2.1-1 portrays the assignment of reliability tasks.

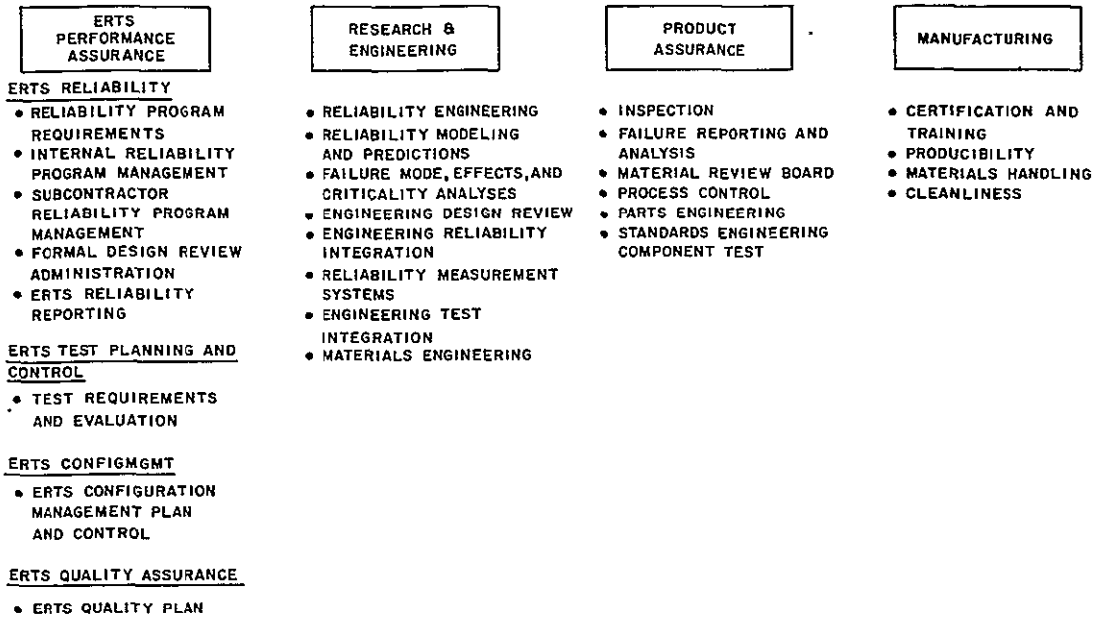

Figure 9.2.1-1. Reliability Assignments

9.2.2 RELIABILITY PROGRAM PLAN

This plan represents the proposed reliability program tasks to be conducted during Phase D of the ERTS A & B Observatory Spacecraft Program.

9.2.3 RELIABILITY PROGRAM REVIEWS

Reviews of reliability program progress and effectiveness will be held concurrent with other major program milestones and are presently planned to coincide with the "preliminary design review", the "hardware review" and the "flight readiness review".

The ERTS Reliability Manager shall submit proposed agendas to NASA/GSFC 2 weeks prior to each reliability program review in order to allow for adequate preparation. Action items resulting from the reviews will be assigned, coordinated, and resolved by the ERTS Reliability Manager.

9.2.4 RELIABILITY PROGRAM CONTROL AND MONITORING

Control and management of the Reliability Program, throughout the life of the contract, is achieved primarily through the implementation of three key activity areas:

1. Delineating reliability requirements and constraints

2. Auditing and evaluating conformance to the requirements and constraints

3. Maintaining management visibility into the reliability program

9.2.4.1 Reliability Program Requirements and Constraints

Reliability requirements on the ERTS Program are established by way of the System Specification (SVS 7760), the statement work, and the reliability program plan, and include the following provisions:

1. Mission reliability requirements
2. Provisions for a parts, materials and processes program and control through use of approved parts
3. Design change control
4. Failure reporting and analysis
5. Subcontractor and supplier control
6. Design review program
7. Testing and reliability evaluation

These requirements and constraints cause implementation of specific reliability program tasks as defined elsewhere within this program plan.

9.2.4.2 Reliability Program Audit and Evaluation

Selection of reliability program monitoring points (milestones) is such that definitive activities are identified and at each point data are provided for objective reviews and evaluation of program status and reliability growth. Activities and milestones are selected such that each activity:

1. Has a significant effect on the reliability of the system
2. Is done in accordance with an established formal procedure
3. Is planned and scheduled
4. Is formally recorded and/or reported
5. Is such that it can be measured/evaluated

The following tasks have been selected as the activities to be audited/monitored by the Manger, ERTS Reliability.

1. Preparation and updating of program documentation
    a. Reliability program plan
    b. Approved parts list

c. Approved materials list

d. Approved processes list

e. Reliability progress reports

2. Hardware oriented tasks

a. Specification changes (Component and Subsystem)

b. Apportionments

c. Reliability predictions and estimations

d. Failure mode, effect and criticality analyses

e. Preliminary design reviews

f. Qualification status/flight qualification review

g. Failure reporting, analysis and corrective action activity

h. Flight readiness review

Tracking of the above activities in terms of schedule conformance, manpower expenditure and task status (as measured/evaluated for degree of completeness and/or content at each milestone), both for in-house and subcontracted work, has proven effective in the assessment of reliability program progress and timely identification of reliability problem areas.

Figure 9.2.4-1 shows a typical design/fabrication cycle on which is superimposed the reliability activities, cited above, selected for audit and evaluation in order to determine the reliability status of the ERTS System. Figure 9.2.4-2 is an expansion of the parts definition/procurement cycle, indicated in condensed form in Figure 9.2.4-1. Note, also, in both figures, specific interaction points at which the Government (NASA/GSFC) formally participates in the design and non-conformance decision-making process.

9.2.4.3 Management Visibility

In addition to regular reporting on the reliability program through the Manager, ERTS Reliability, weekly status reports, monthly progress reports and regularly scheduled program management reviews all contain significant reliability program events as a separate topic.

9.2.5 RELIABILITY INDOCTRINATION AND TRAINING

A separate and formal reliability indoctrination and training program is not planned for the ERTS Program. Rather, GE will continue with its proven reliability and design practices and through preparation of design review checklists draw attention to peculiar and/or unique aspects of the ERTS equipment design.

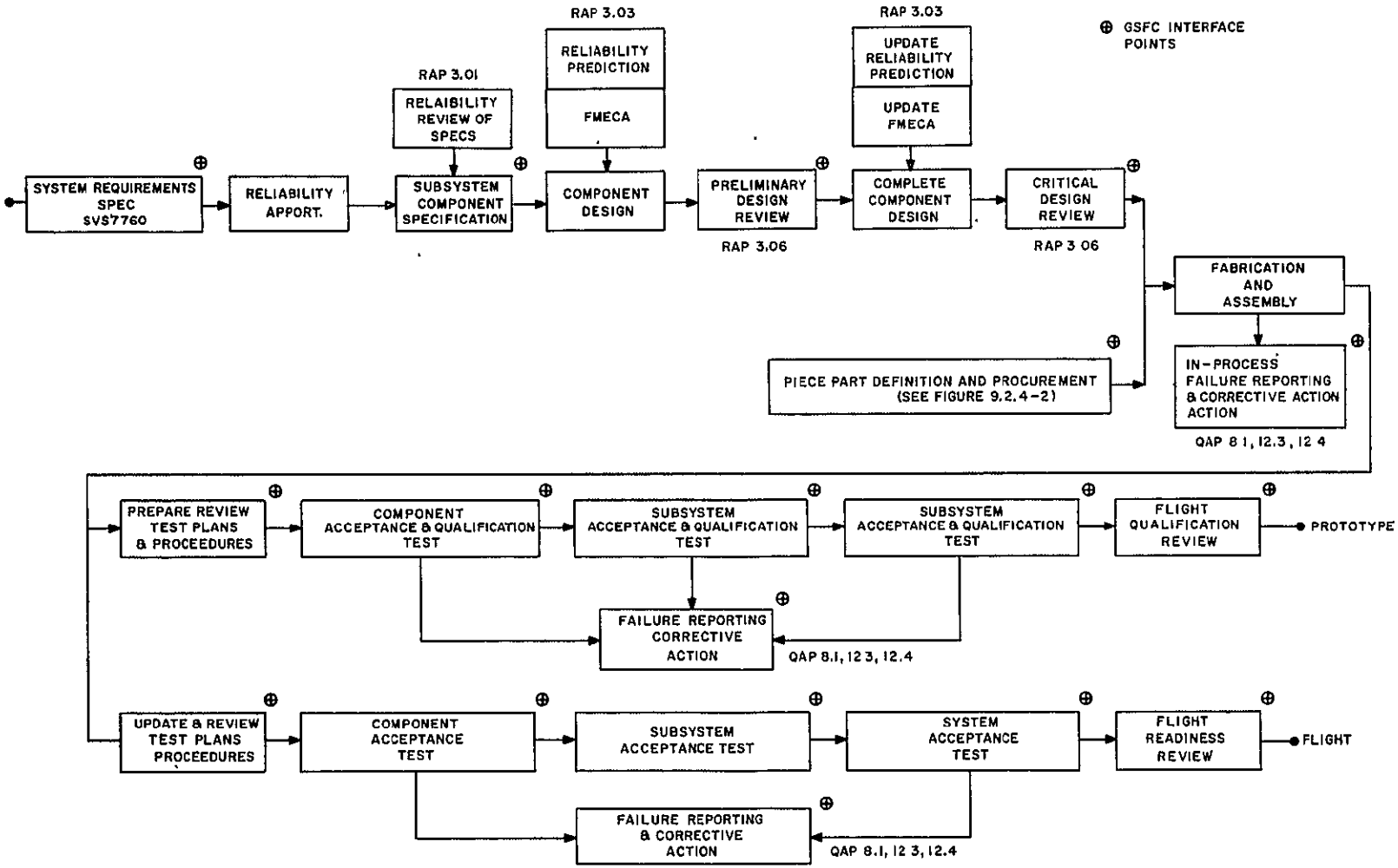

Figure 9.2.4-1. Typical Reliability Activities During the Design/Fabrication Cycle

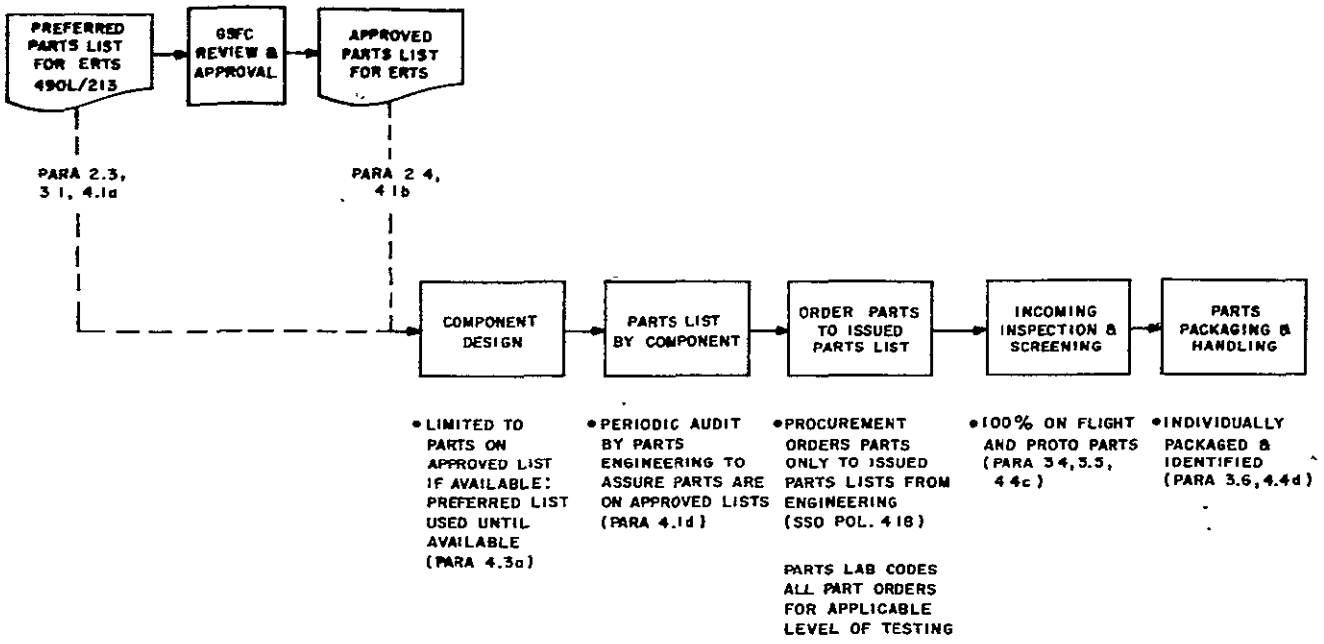

Figure 9.2.4-2. Parts Definition/Procurement Cycle

9.2.6 SUBCONTRACTOR AND SUPPLIER CONTROL

Assuring a proper reliability program at the subcontract level is of paramount importance in achieving required reliability of the delivered flight system, GE has adopted the following four-step program to achieve this end:

1. Establishing essential reliability program requirements consistent with those at the prime contract level, and imposing them uniformly on new designs from all major subcontractors (Reference 69SD5227 "Reliability Requirements for ERTS Subcontractors" reproduced as Appendix A of this Section).

2. Through the process of subcontractor selection, including review of proposed reliability programs, fact finding and negotiation, assuring that the subcontractor fully understands, is capable of implementing and has made proper provisions for the required reliability program.

3. After contract award and prior to the first major reliability milestone (such as preliminary design review or hardware review), the Manager, ERTS Reliability and/or a senior member of his staff will visit each subcontractor and assure that the established and agreed-upon Reliability Program is, in fact, in place and functioning properly.

4. Finally, as is more typically standard practice, the subcontractors reliability program is tracked and monitored at major reliability and/or program milestones such as discussed in Section 9.2.4.2.

This program approach, places emphasis on getting off to a well directed, mutually established and understood start - an essential strategy for delivery of high-reliability, long-life hardware in a cost-effective manner.

Significant elements of the subcontractor reliability program include the following (all references are to Document 69SD5227, (Appendix A), unless otherwise stated):

1. Requirement to establish single-point authority for the implementation of the subcontractor's reliability program (Para. 3.1) consistent with the position of the Manager, ERTS Reliability at General Electric.

2. Holding the subcontractor responsible for the reliability of his delivered equipment (Para. 1.0) with additional provisions for review and approval by General Electric of his parts stress analysis report(s), FMECA(s), failure reports, failure analysis reports (reference Data Requirements List, page A-12), Preferred Parts and Materials Lists, and Parts Screening (ref. Document 69SD4379 in the Parts Program Plan).

3. Review of the Subcontractor's reliability program and design progress is specifically prescribed per reliability program review (Para. 3.1.2) and design review (Para. 3.8).

9.2.7 CONTROL OF GOVERNMENT FURNISHED PROPERTY (GFP)

The Reliability and Design Review Manager will request complete reliability data direct from NASA/GSFC for all payload components and/or subsystems supplied for use on the spacecraft system. No specific reliability evaluation of GFE is planned by GE Space Systems.

Appropriate procedures in handling, assembly, and test will be instituted to assure that existing reliability of the GFE item(s) is not degraded. GE Space Systems will require necessary documentation to allow for the performance of incoming inspections, testing and operation of the equipment. All failures and malfunctions of GFE items while under contractor control will be reported directly to NASA/GSFC. Repair or other correction of failed GFE items will be in accordance with the government property clause specified contractually.

9.3 RELIABILITY ENGINEERING

9.3.1 GENERAL

Reliability activities during the design and development phase of the program have the greatest potential impact on overall program reliability, for it is at this time that the integrity of the system design and hardware design is established, on which all else depends. An essential requirement of the reliability engineering tasks is the systematic removal of design defects and other deterrents to high reliability before they are incorporated into the hardware.

Each of the basic elements of the reliability engineering program described in the following paragraphs contributes in some manner to the detection and removal of systematic design and manufacturing defects. Many of the elements, due to their proven contribution to defect identification and removal, are actually a part of the in-line engineering design effort, contributing in real-time rather than being used as an after-the-fact audit.

9.3.2 DESIGN SPECIFICATIONS

The Reliability engineering group will review all design specifications for conformance with reliability program requirements and adequacy of referenced specifications and standards. Special attention will be focused on the design requirements and quality assurance provisions. Prescribed test procedures will be reviewed to determine suitability of technique and adequacy of environmental test levels.

9.3.3 RELIABILITY PREDICTION AND ESTIMATION

9.3.3.1 Reliability Apportionment

Program reliability goals and definitive success/failure criteria, once agreed upon by General Electric and NASA/GSFC, will be translated/apportioned into system, subsystem and component reliability goals. Comparison of apportioned goals with preliminary reliability estimates will permit identification of potential reliability problem areas where derived success probabilities fall out of line with apportioned values.

An initial apportionment is included in the ERTS Phase B/C SSO Final Report with updates planned to accommodate changing program needs, changes in system configuration and revisions to mission duty cycles of the spacecraft's equipments and experiments.

9.3.3.2 Reliability Math Models

Reliability math models/block diagrams derived during Phase B/C will be updated and maintained during the Phase D effort to reflect changing program needs and changes in system configuration. These models will reflect the functional relationship of the primary equipment as well as built-in redundancy, back-up operational equipment and alternate operational modes.

9.3.3.3 Numercial Reliability Estimation

Numerical reliability estimation is an analytical process wherein representative failure rates are applied to the above-mentioned reliability models/block diagrams followed by standard probability addition/multiplication calculations to yield integrated failure rates

whenever possible. This failure rate and the operating time, derived from the mission and experiment operating profiles, is then entered into the appropriate reliability equation to calculate equipment reliability for the mission profile of interest.

In performing the above calculations, certain basic assumptions are inherent and hence their validity must be separately verified in each application. Following is a brief summary of the major assumptions and an indication of which part of the proposed reliability program serves to either verify the assumption or at least increase the probability of it being valid:

1. Reliability is normally considered to be a function of so-called "random" failures. This requires that part screening and burn-in and hardware testing eliminate infant mortality failures and workmanship and/or other human-induced defects. Also required are effective design and design review practices so as to prevent/divert design defects and assure that required duration of equipment operation is within practical wear-out limits of the piece-parts and other hardware elements.

2. The component design has basic functional integrity. As above, assurance is required that systematic design defects have been removed which includes assurance that the design exemplifies proper piece-part application and that part derating is consistent with program requirements. The parts application review described in Section 9.3.3.4 is an important factor in this determination.

   In the case of previously qualified flight-proven hardware, additional assurance regarding design adequacy is gained through the accumulated experience. However, especially in these cases, extreme care must be exercised to assure that the present application does not invalidate previous experience. In addition to engineering analyses, the design review program is a significant factor in this determination.

3. The dominant failure stresses and predominant mode or modes of failure are known. This information is necessary to determine the failure rates on individual parts at the level of dominant stresses and to provide design precautions such as additional derating and/or redundancy to compensate for probable critical failure modes.

   The parts application reviews and failure mode effect and criticality analyses provide most of this information.

In view of the indicated limitations, this compilation of past experience on generically similar parts and components provides quantitative engineering estimates of reliability potential and is an extremely useful tool in determining the feasibility of achieving a particular reliability goal.

The preliminary system estimate, derived in Section 4.1 of Volume I of this report indicates the ERTS system as presently configured is capable of exceeding a 0.71 probability of success for the 1-year mission. Continuing analytical and modelling effort during the early

portion of the Phase D contract will further investigate the validity of the failure rate data sources and provide further insight into "degraded" backup modes of operation from which substantial mission data may still be derived.

9.3.3.4 Parts Application Review

An essential aspect in designing for reliability is not only the selection of proper piece-parts but also assuring their proper application in each component design according to its mission profile requirements (including environment). These part stress analyses shall be based on the mechanical, electrical, thermal, acoustical and environmental stresses acting on the parts and circuits and will result in identification of actual derating factors, and dominant failure stresses. Through this information, most likely failure modes may be defined and assurance is gained that all piece-parts are applied consistent with established program derating philosophy. The latter factor, in itself, is important in assuring that proper failure rates are being applied in the reliability estimation task.

Preliminary parts application reviews will be included as a part of Preliminary Design Review (PDR) with final and detailed analysis to be completed prior to, and reviewed as a part of, Hardware Design Review (HDR) on each component. To the maximum extent possible, use will be made precisely completed analyses on existing equipment.

9.3.4 FAILURE MODE, EFFECT AND CRITICALITY ANALYSES (FMECA)

The failure mode, effect and criticality analysis is essentially derived from a detailed and systematic review of a component design looking not for the ways the component will work but, rather, for ways in which the component can fail to meet its functional performance requirements, and the causes or hazards that would precipitate these failures. The objective of this search is to discover critical failure areas and to remove susceptibility to such failures from the system and/or to minimize the probability of such failures occurring. As such, these FMECA's are inherently engineering analyses associated with effective design practices and, to be of maximum value, must be accomplished in real time as the design evolves rather than after-the-fact as an audit. This is accomplished at General Electric by assigning primary responsibility for the analyses to the functional design engineers with assistance and support provided by reliability engineers to the extent required.

FMECA's at the component level will be conducted down to the circuit/subassembly level.

Preliminary FMECA's will be prepared on all components, subsystem and the system for PDR and will be updated/finalized for HDR. To the maximum extent possible, use will be made of previously completed analyses on existing equipment.

9.3.5 MAINTAINABILITY AND ELIMINATION OF HUMAN INDUCED FAILURES

Maintainability consideration will be continued as a design factor during Phase D, primarily directed at the failure/repair cycle at and above the component level. The objective is to minimize handling and disassembly associated with identifying, gaining access to, and replacing a failed component in order to help insure that undetected failures are not induced into the spacecraft.

Maintainability design guidelines, and other checklists, will be utilized during internal design reivews to identify maintainability problems and opportunities for human-induced failures.

9.3.6 DESIGN REVIEW PROGRAM

9.3.6.1 Objective

The objective of the Phase D design review program is to establish a series of constructive and positive examinations and analyses of the system, subsystems and components for the purpose of:

1. Surfacing latent defects in the design solution presented
2. Assuring that all requirements are necessary and sufficient and that design solution meets these requirements in an effective manner
3. Developing an effective course of action for the resolution of problem areas identified.

9.3.6.2 Design Reviews by the Contractor

The overall design review program encompasses two general types of assessments: formal and informal. Two formal design reviews (preliminary design review and hardware design review) are planned at the spacecraft level. It is planned to conduct these two reviews at the GE VFSC Pennsylvania facility with GSFC serving as review chairman and General Electric Company serving as co-chairman. The purpose of these formal reviews is to provide GSFC, through their critical audit of the design, assurance that the design solution will meet the design requirements set forth in the formally approved Specification. NASA/GSFC, or their designated representative, as appropriate, will be notified 15 days in advance of each formal design review regarding the scope, content, date and location of the review and will be provided descriptive information on the equipment being reviewed.

In addition to the above formal design reviews, General Electric will also hold internal design reviews, governed by the system functions involved, the complexity of the design and the "newness" of the design. All new equipments will be reviewed at least twice: once at completion of preliminary design definition and again prior to final design release for fabrication. On existing, flight qualified equipment to be used "as is," at least one internal review will be held prior to final design release for fabrication. As noted before, one essential determination is that the proposed application on ERTS is fully compatible with previous applications and in no way invalidates established confidence. On modified equipments, the number of reviews will be governed by the degree of change; however, in all cases, at least one final review will be held as for existing equipments above.

These internal reviews are formally documented with minutes identifying personnel attending, all action items established as a result of the review, and responsibilities assigned and schedules for action item closeout. The design review chairman will follow-up on action item closeout and will report regularly to the ERTS Program Manager regarding the status and impact of open action items.

9.3.6.3 Design Reviews by Subcontractors

Through Document 69SD5227, (Appendix A) "Reliability Requirements for ERTS Subcontractors," and statements of work on the major component and subsystem procurements, GE Space Systems has invoked formal design review requirements on subcontractors consistent with the above requirements for internal design reviews: specifically, at least two design reviews on all new or modified equipments and at least one review on existing, space qualified equipment to be used as is.

9.3.6.4 Engineering Design Changes

Subsequent to design review on any given item, each engineering design change shall be reviewed for impact not only on the reliability of the design but also on the validity of previously completed design reviews. When the nature of the change so warrants it, another formal design review will be convened prior to issue of the change to consider at least the specific change and whatever other aspects of the given item are directly affected by the change.

9.3.6.5 Other Reviews

Upon completion of prototype qualification, NASA/GSFC will examine associated test and failure data and also verify the adequacy of handling and test procedures and plans as exemplified by the processing of the prototype test vehicle. Similarly, upon completion of flight acceptance testing and prior to lift-off of each flight system, review of test and any failure data is expected to establish the readiness of the flight spacecraft to proceed into the launch sequence.

Pertinent test and failure data on all testing is, however, carefully scrutinized by reliability engineering personnel to determine impact on the validity of completed design reviews, FMECA's, parts and materials application reviews, and reliability assessments. Reliability engineering is thus cognizant of the hardware through its total life cycle, preliminary design through flight.

9.3.7 FAILURE REPORTING AND CORRECTION

The failure reporting and correction plan is carried as a separate plan in Volume 3, Section 7 of this report.

9.3.8 STANDARDIZATION OF DESIGN PRACTICES

Design and Process Standards will be used in order to assure a uniform approach to the design and fabrication of hardware and to provide reliability through the use of proven techniques. Such standards are already in existence and under constant surveillance to assure applicability to the project and to provide current state-of-the-art status.

9.3.8.1 Design Standards

Design Standards are documents containing proven and standard methods in approaching and solving technical problems related to spacecraft hardware during the design phase. Additionally, such guidelines establish uniformity in practices and hardware conforming to optimum reliability achievement.

The scope of design standards includes the basic physics such as behavior of high voltage in spacecraft, production hardware configuration such as printed wiring boards processes such as cleanliness control, and materials.

9.3.8.2 Fabrication Standards

Standards for establishing fabrication techniques and the quality acceptance criteria of the hardware produced by various production activities are mandatory by drawing callout. These documents include generic subjects such as specific assemblies like thick film microelectronics and process procedures such as nondestructive radiological inspection.

9.3.9 PARTS AND MATERIALS PROGRAM

The parts program is defined in Section 3 of this Volume of the study report. Materials and processes are defined in Section 4 of this Volume.

9.3.10 EQUIPMENT LOGS

See the ERTS quality program plan, Section 2 of Volume 3 of this report, for coverage of equipment log generation and maintenance.

9.4 TESTING AND RELIABILITY EVALUATION

9.4.1 GENERAL

The ERTS A&B Observatory Spacecraft Program, like other high-reliability, long-life, space programs, will be lacking sufficient pertinent test data to provide classical reliability requirements demonstration at a meaningful confidence level. On the other hand, the testing conducted on the program is the only hard data available with which to evaluate operational reliability - that is, whether or not the spacecraft system will operate successfully and fulfill mission objectives. The plan for achieving "operational reliability" is based on two primary factors:

1. Insight regarding the nature of defects detected in previous space programs

2. Accumulation of operational experience.

Both of these factors are discussed in the following sections.

9.4.1.1 Nature of Defects Discovered

An extremely important observation made from the evaluation of causes and sources of ground and flight failures accumulated on more than seven major, complex, long-life spacecraft programs is that defects of a systematic nature are a major cause of flight failures. (A defect, in this context, is a condition existing in the hardware whose manifestation results in a hardware failure/malfunction. Also, "systematic nature" implies that the defect will be present every or almost every time the item is built according to the existing drawings and processes). This defect-type is not eliminated by replacement/repair with other items fabricated according to the same design; the design and/or fabrication process must be changed to eliminate the failure source (i.e., the defect). Fortunately, the systematic type of defect is eligible for detection at many stages of the hardware evolution process. For example typical defect removal "screens" include design analyses; design reviews, parts application reviews development tests and qualification tests. In addition, flight acceptance tests have also been found effective in the detection of this defect type. Of particular significance on ERTS is the high proportion of previously designed, qualified and flown equipment. Analyses have indicated that the most significant factor in the elimination of latent design defects in a given design to be repeated exposure of the design concept to a large number of sequential defect removal screens. For this system, 86 percent of the "boxes" (54 out of 63) are previous proven designs being used "as-is" or with only slight modification that does not negate the established design integrity.

The nature of the other class of defects found may be termed "non-systematic," implying that their presence is typically limited to a specific hardware item, and that other pieces of hardware, built according to the same drawings and processes, is not likely to contain the same defect. Under these circumstances, repair/replacement is an effective corrective action. Workmanship problems and random piece-part failures typically fall into this classification. Experience has shown that in-process and flight acceptance tests are very effective in removing this type of defect. In terms of the above classification of defect types, effective failure reporting and analysis is seen to be critical - particularly in the

determination of failure cause. Repair/replacement corrective action, when the cause is systematic in nature, will not remove the failure source - the defect will be present in the new items perhaps to manifest itself again as a failure. On the other hand, to redesign when the failure source is non-systematic in nature causes unnecessary, and often prohibitive, cost and schedule impact to the program.

Two environments found particularly effective in the detection of defects (both systematic and non-systematic types) are vibration and thermal vacuum. Vibration testing will be conducted typically at two levels of assembly (i.e., component, and system levels) and, whenever possible, functional performance of the equipment will be monitored during vibration. Of interest is the detection of intermittent failures which are not apparent in steady state test like pre-and post-vibration bench checks. In most cases, the above vibration testing will be followed by testing in a thermal vacuum environment where, again, functional performance will be evaluated not only at steady state conditions but also during transients from one state to another; this, again, to detect those potential failures which exhibit themselves only during non-steady-state conditions. In some cases, the environments so induced may exceed on-orbit specification limits. In these cases, success/failure criteria must be modified to permit predictable performance in excess of specification limits. Specifically, unanticipated and/or unexplainable performance variations - either within or in excess of specification limits - will be cause for further investigation to verify whether or not a failure is present. (It should be noted that, although on-orbit specification limits may be exceeded, care will be taken to ensure that the induced environments will not inflict damage to the operating component.) Where, in fact, performance remains satisfactory, even under a typical environmental transients, information is derived regarding capability margin - a necessary factor in achieving reliable space flight.

9.4.1.2 Cumulative Test Experience

One objective of the integrated test program, from an operational viewpoint, is to provide for the accumulation of test data from all sources in order to determine spacecraft performance characteristics. From this data, a reference/baseline of anticipated flight performance is derived which will be used in on-orbit analysis for the detection of potential malfunctions. For Flight A this data bank will at least include results from the structural dynamics model, thermal model and bench integration testing as well as Flight A ground testing while for Flight B, additional data is accumulated via Flight A and Flight B ground test. As the operational performance baseline becomes more sharply defined with additional pertinent data accumulation, so is the ability to detect minor performance variations indicative of incipient failure; and, through the identification of a defect, the opportunity to correct it.

9.4.2 RELIABILITY EVALUATION PLAN

Due to the lack of statistically significant data (in the reliability sense) expected on the flight configurations, evaluation of reliability is not planned to include the changing of design reliability estimates and/or block diagrams. Due to this fact, test results will be used to provide qualitative assessments of reliability and will generally be directed at evaluation of "performance capability" of the system. The test program is subject to continuous review by Reliability Engineering with emphasis mainly on the ability of the test program, as designed

and implemented, to detect latent defects in the system, this factor having direct bearing on the "operational" reliability to be realized on Flights A and B.

9.4.3 TESTING

9.4.3.1 Scope

The scope of testing planned for the ERTS Phase D Program is contained in Volume 2, Section 10 of the Study Report, "Integration, Test and Launch Support."

9.4.3.2 Concept of Testing

As discussed above in Sections 9.4.1 and 9.4.2, reliability test evaluation on the ERTS Program involves the utilization of test data gathered to provide assurance that expected performance capabilities (as designed) exist in the equipment (as built) and to determine the existence of unanticipated failure mechanisms. Every test run (i.e., from breadboard through flight acceptance testing) is potentially eligible to contribute to the detection of systematic-type defects. The flight acceptance test sequence has also another duty; that is, the detection of any non-systematic defects in the specific hardware to be flown.

Based on analyses of defects, discussed in Section 9.4.1.1 above, a reliability test criteria has evolved requiring that flight hardware be exposed to a minimum of three serial test screens prior to launch. In this context, a test screen is defined as a test in which the specific equipment is functionally exercised and either during or subsequent to which equipment malfunctions would normally be detectable.

Table 9.4.3-1 shows a summary of test exposure relative to five generic test screens at or above the component level (i.e., component acceptance test, subsystem acceptance test, system integration testing, and field and launch performance tests). As shown, at least three serial screens are indicated for all hardware units. In addition, the philosophy of 100 percent parts screening for ERTS assures initial conditioning of piece parts prior to incorporation into the prime hardware units.

Specific implementation of the above reliability test criteria comes with preparation of detailed test plans and procedures, to be accomplished during Phase D. Note again, however, that present plans already include provisions to provide a minimum of three serial test screens at or above the component level for all flight hardware units.

9.4.3.3 Test Specifications, Procedures and Reports

GE, in the Integrated Test Plan will include at least the following testing to be conducted during Phase D:

1. Qualification and acceptance testing

2. Spacecraft tests to be performed at the launch site

3. Checkout testing of aerospace ground equipment

Table 9.4.3-1. Equipment Exposure by Test Screen

Subsystem	Component Acceptance Testing	Subsystem Acceptance Testing	System Integration Testing	Systems Acceptance Testing	Field and Launch Performance Tests	Number of Serial Screens
Orbit Adjust	X	X	X	X	X	5
Attitude Control	X	X	X	X	X	5
Thermal Control	X		X	X	X	4
Power	X		X	X	X	4
Electrical Integration	X		X	X	X	4
Structure and Separation	X	X		X	X	4
Command and Data Handling	X		X	X	X	4
Communications	X	X	X	X	X	5
Payload	X		X	X	X	4

For each test described in this plan, separate and detailed test specifications, test procedures and test reports shall be prepared.

9.4.3.4 Reliability Demonstration Tests

Testing for the sole purpose of statistically demonstrating numerical reliability is not planned on the ERTS Program.

9.4.4 RELIABILITY ASSESSMENT

Formal reliability assessment will occur via review of reliability estimation work and FMECA's.

Test results and/or failure data will be reviewed as part of an on-going and continuing assessment of reliability.

9.4.5 RELIABILITY EVALUATION PROGRAM REVIEWS

Reliability participation in the Design Reviews will constitute the Reliability Evaluation Program Reviews.

9.5 DOCUMENTATION OF RELIABILITY PROGRAM

9.5.1 GENERAL

The GE reliability effort is documented via the plans, reports and analyses initiated in response to reliability program task requirements. Certain of this information is used for "Reliability Program Audit and Evaluation" as discussed in Section 9.2.4.2. As noted in Sections 9.1.4.1 and 9.1.6, submission of reliability program data to NASA/GSFC shall be as prescribed in the Data Delivery Schedule of the Work Breakdown Statement governing this contract. In any case, the ERTS Reliability Manager, discussed in Section 9.2.1, will maintain a central file containing all reliability documentation generated on the program.

9.5.2 RELIABILITY PROGRESS REPORTS

9.5.2.1 Weekly Summaries

The program Weekly Status Reports will contain signficant reliability program information including a listing of all failures which occurred during the previous week.

9.5.2.2 Periodic Progress Reports

The program Monthly Progress Reports will also include a report on the progress of reliability program tasks including specific accomplishments, reliability problem areas, and significant program decisions/actions having impact on the reliability program.

9.5.3 SUMMARY OF TECHNICAL DOCUMENTATION

Technical documentation of the reliability program activities is discussed in Section 9.5.1.

APPENDIX 9.A

RELIABILITY REQUIREMENTS

FOR

ERTS SUBCONTRACTORS

11 February 1970

DOCUMENT NO. 69SD5227
December 22, 1969

RELIABILITY REQUIREMENTS

FOR

ERTS SUBCONTRACTORS

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APPROVED BY: D. N. Keller 27 Dec. '69
D. Keller, ERTS Program Manager

TABLE OF CONTENTS

1.0 SCOPE

11 February 1970

This document prescribes the reliability program requirements imposed on ERTS Subcontractors, and subcontracted items utilized on the ERTS project. It also provides criteria by which the sub-contractor shall plan and implement a reliability program to meet these requirements. The provisions specified herein conform to the general requirements of NASA Document NPC 250-1, "Reliability Program Provisions for Space Systems Contractors", dated 30 July 1963.

The Sub-contractor shall be responsible for the reliability of his delivered equipment, and the reliability of the equipment delivered by his lower tier suppliers.

1.1 Relation to Other Contract Requirements

All requirements specified herein shall apply to the Subcontractor except as specifically amended or excluded in the Statement of Work. The requirements of this specification shall not be superseded, deleted, or modified by any documents prepared by the Subcontractor without the consent of General Electric.

Any inconsistency between the requirements of this document and any other specified document except the Statement of Work shall be brought to the attention of the GE ERTS Technical Officer for interpretation.

1.2 Purpose

The basic objective of this document is to prescribe the reliability program activities/requirements deemed necessary to assure the reliability of the procured item, and the optimization of system reliability.

2.0 APPLICABLE DOCUMENTS 11 February 1970

The following specifications, standards and publications form a part of this document to the extent specified herein:

MIL-HDBK-217A "Reliability Stress and Failure Rate Data for Electronic Equipment" 12 Jan 1965

PPL-10 NASA/GSFC Preferred Parts List

3.0 REQUIREMENTS

11 February 1970

The following requirements shall apply during this subcontract. Any deviation from these requirements shall require the prior approval of General Electric.

3.1 Reliability Management

The Subcontractor shall establish a single source of responsibility for the implementation of a reliability program consistent with the requirements of this specification. This single source of responsibility shall act as the principle reliability contact representative of the Subcontractor, and shall have the delegated authority to enforce reliability policies and ensure necessary actions.

3.1.1 Reliability Program Plan

The Subcontractor shall prepare an ERTS Phase D Reliability Plan in response to this Subcontractor Reliability Requirements Document and shall submit the plan to GE ERTS for review and approval in accordance with the Statement of Work. The Subcontractor shall identify all Phase "D" reliability tasks, including description, time-phasing, and manloading per task. Recurring tasks and the basis for the same shall be explained. General Electric will review and approve/disapprove the plan in accordance with the Statement of Work.

3.1.2 Reliability Program Review

The Subcontractor shall monitor and control the reliability program to assess its progress and effectiveness and to determine the need for adjustments or changes. General Electric and the Subcontractor will jointly conduct informal reviews of the reliability program.

3.1.3 Defect Identification and Control

The Subcontractor shall actively and systematically pursue identification of defects and/or other sources of unreliability and implement corrective action for elimination of such items. Normal program activities such as design review, engineering analysis, testing, failure analysis, etc. are expected to contribute to this activity.

3.2 Supplier Control

3.2.1 Supplier Reliability Program

The Subcontractor shall invoke applicable reliability requirements on his suppliers.

3.2.2 Supplier Selection

The Subcontractor shall develop and apply reliability criteria for and in the selection of his suppliers.

3.3 Subcontractor Equipment Specifications

The Subcontractor shall incorporate applicable reliability requirements in all design specifications he generates.

3.3.1 Specification Changes

The subcontractor shall specifically include assessment of impact on reliability of all specification change actions submitted to General Electric as an ECP.

3.3.2 Design Margins

The Subcontractor shall identify the design margins for his specified equipment prior to design release and shall identify which of the specified design margins are to be verified by analysis and which are to be verified by test. Method of analysis and/or type of test (e.g., development test, qualification test, etc.) shall also be identified. This information shall be a part of the Critical Design Review (CDR) Package (ref. par. 3.8).

3.4 Reliability Prediction and Estimation

3.4.1 Apportionment

The reliability requirement shall be as specified in the hardware specification, para. 3.1.2.1, as defined in the statement of work to which this document is attached. The subcontractor shall allocate the imposed reliability requirement to the components ("Black Boxes") for which he has responsibility.

3.4.2 Reliability Math Models

The Subcontractor shall develop reliability math models based on the design configurations, and will submit the selected configuration reliability mathematical model for the preliminary design review. The model will be updated as the design cycle progresses.

3.4.3 Part Stress Analysis (Reliability Estimation) 11 February 1970

The Subcontractor shall conduct a part stress analysis on all components ("Black Boxes"). The analysis shall be based on the mechanical, electrical, thermal and environmental stresses acting on the parts, circuits, etc., and the expected part failure rate resulting from such stresses.

The following ground rules shall govern the analysis:

a) All reliability calculations shall utilize failure rates approved by General Electric. The Subcontractor shall submit a proposed list of "Failure Rates for ERTS Parts", for all parts which have no comparable rates in the referenced specification contained in paragraph 2.0. The list shall contain the part identification, higher assembly identification, proposed failure rate and failure rate source (flight experience,handbook, etc.).

b) The part stress analyses shall be documented on forms (worksheets) which contain at least the following data elements:

1) Part Type
2) Circuit Symbol Number
3) Manufacturer
4) Value
5) Manufacturer's Rating
6) Applied Stress
7) % of Manufacturer's Rating
8) Maximum Temperature
9) Maximum Rated Temperature
10) Failure Rates
11) Failure Rates Source (if not approved list in (a) above).

c) Part derating factors shall not exceed those found in (TBD).

d) The part stress analysis worksheets will serve as a basis for reliability estimation.

3.4.4 Part Stress Analysis Report

A Part Stress Analysis Report shall be prepared for each component ("Black Box") and shall include the following elements as a minimum:

a) Part Stress Analysis

b) Reliability Block Diagram

c) Reliability Estimate (at the component - "black box" level) derived from a) and b) above.

d) Recommendations and conclusions, including corrective action taken if prediction does not meet apportioned reliability value

and shall be submitted as part of the data package required for design review.

In cases where previous longterm flight history (> one year) exists for duplicate circuits, assemblies or black boxes, this information shall be entered on the analysis worksheets in lieu of the specified data.

3.5 Parts, Materials, Processes and Standards

The Subcontractor shall comply with the Parts, Materials, Processes, and Standards program defined in G.E. Document 69SD4379.

3.6 Failure Mode, Effect and Criticality Analysis (FMECA)

The Subcontractor shall conduct a FMECA down to the part level on all components ("black boxes") or subsystems included in the statement of work to which this document is attached. These analyses shall be conducted and maintained current throughout the design stage to determine the possible modes of failure which may be eliminated or minimized by corrective design action.

In cases where previous longterm flight history (> one year) exists for duplicate circuits, assemblies or black boxes, this information shall be entered on the analysis worksheets in lieu of the specified data shown in Paragraph 3.6.1.

3.6.1 FMECA Format

The data elements required for entry onto the Failure Mode Analysis Worksheets are, as a minimum:

a) The name of the assembly

b) The drawing number by which the Subcontractor identifies the assembly.

c) Circuit/subassembly designation shown on the schematic.

d) Concise statement of function performed by circuit/subassembly.

e) Predominant failure modes of the circuit/subassembly

f) Cause or mechanism which precipitated the failure mode.

g) The probability of the occurrence of the failure mode.

h) The effect the failure has on the next higher level of assembly. (component or subsystem).

i) The provisions in the design to eliminate or alleviate the failure.

3.6.2 FMECA Report

The FMECA Report shall include the folloiwng elements as a minimum:

a) FMECA Worksheets

b) Summary of critical failures in descending order, and design action to be undertaken to eliminate the same.

c) Conclusions and recommendations.

and shall be submitted as part of the data package required for design review.

3.7 Reliability Reporting

Monthly reports on the status of reliability activities will be prepared by the Subcontractor for transmittal to GE as a part of the monthly program report required by the Statement of Work.

Reports will include, but not be limited to, the following sections:

(1) Technical Progress - Significant achievements that occurred within the reporting period; the cumulative status of the reliability effort versus the scheduled program; scheduled changes required, etc.

(2) Review of Significant Events - Comments on the major design changes and their effect on reliability; analysis of significant failures occurring during the reporting period; discussion of current and/or anticipated reliability problem areas, with recommendations for solution, etc.

Reports will be submitted to the ERTS Technical Officer as a part of the monthly program report required by the Work Statement.

3.8 Design Review

The Subcontractor shall establish and conduct a program of planned, scheduled and documented design reviews. These reviews shall be comprehensive audits of all pertinent aspects of the design, particularly its reliability, and shall be conducted at established major milestones in the Program as prescribed in the Program Plan.

As a minimum, at least one design review (Critical Design Review) shall be held for each existing equipment and at least two design reviews (Preliminary Design Review and Critical Design Review) shall be held for each new or modified equipment.

3.8.1 Design Review Data

The subcontractor shall submit six (6) copies of the following data to the extent available, to General Electric per the data requirements list in Section 4.0.

a) Applicable Specifications

b) Applicable Drawings

c) Applicable Test Plans and Procedures

d) Available Test Data and Failure Data

e) Design Margin Verification Requirements (ref. Para. 3.3.2).

f) Applicable Analytical Documents such as:

- Performance Analyses
- Tolerance Studies
- EMI Analyses
- Thermal Analyses
- Dynamics Analyses
- Stress Analyses
- Power Requirements
- Failure Mode, Effect and Criticality Analysis
- Parts Application Stress Analysis and Reliability Estimates

4.0 DOCUMENTATION

The Subcontractor shall submit required reliability documentation according to the requirements and schedules contained in the Statement of Work to which this document is attached.

DATA REQUIREMENTS LIST

ITEM	CONTRACTOR APPROVAL	REFERENCE PARAGRAPH NO.	FREQUENCY OR DUE DATE	COPIES	FORMAT
1. Reliability Program Plan	Y	3.1.1	With Proposal	8	SF
2. Design Margin Verification Plan	RO	3.3.2	With Item 7 at CDR	6	SF
3. Apportionment Report	RO	3.4.1	30D ARO	6	SF
4. Parts Stress Analysis Report	Y	3.4.5	With Item 7 (Updated for CDR)	6	SF
5. Failure Mode, Effects & Criticality Analysis	Y	3.6.2	With Item 7 (Updated for CDR)	6	SF
6. Reliability Progress Reports	RO	3.7	With Monthly Progress Report		SF
7. Design Review Data Package	RO	3.8.2	21 days prior to PDR and CDR	6	SF

Y - Yes
RO - Review
SF - Seller Furnished

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